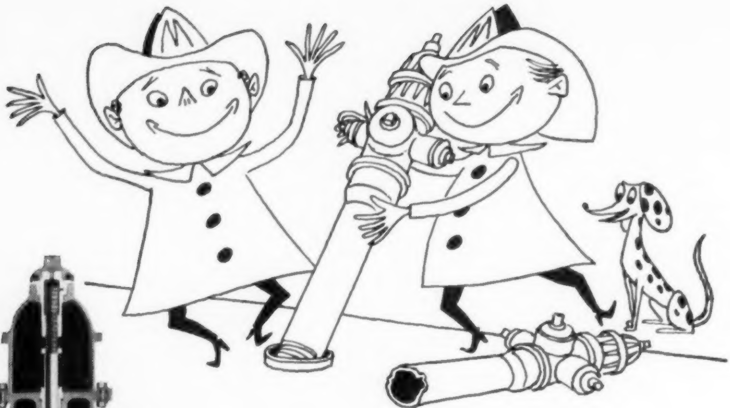
JULY 1953

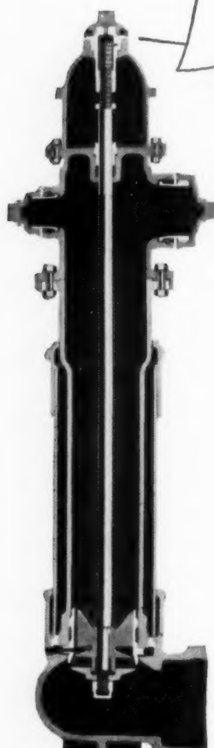
Journal

VOL. 45 • NO. 7

AMERICAN WATER WORKS ASSOCIATION

In this issue





Journal

AMERICAN WATER WORKS ASSOCIATION

July 1953

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Contents

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Coming Meetings

AWWA SECTIONS

Sept. 3–4—West Virginia Section at Hotel Morgan, Morgantown. Secretary, Harry K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston.

Sept. 1–5—Minnesota Section at Royal Alexandria Hotel, Winnipeg. Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul, Minn.

Sept. 3–4—Michigan Section at Hotel Delta, Escanaba. Secretary, T. L. Vander Velde, Chief, Sec. of Water Supply, State Dept. of Health, Lansing.

Sept. 9–11—New York Section at Lake Placid Club, Lake Placid. Secretary, Kimball Blanchard, Rm. 1922, 50 W. 50th St., New York 20, N.Y.

Sept. 10–11—Ohio Section at Hotel Cleveland, Cleveland. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sept. 21–23—Kentucky-Tennessee Section at Hotel Owensboro, Owensboro. Secretary, J. Wiley Finney, Jr., Asst. Director, State Dept. of Public Health, 420 6th Ave., N., Nashville 3, Tenn.

Sept. 22–23—Rocky Mountain Section at LaFonda Hotel, Sante Fe. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

Sept. 22–24—Wisconsin Section at Hotel Pfister, Milwaukee. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

Sept. 27–29—Missouri Section at Elms Hotel, Excelsior Springs. Secretary, Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

Oct. 4–6—Alabama-Mississippi Section at Heidelberg Hotel, Jackson, Miss. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

Oct. 11–13—Florida Section at McAllister Hotel, Miami. Secretary, William W. Aultman, Asst. Director, Dept. of Water & Sewers, Box 315, Coconut Grove Sta., Miami 33.

Oct. 14–16—Iowa Section at Russell Lamson Hotel, Waterloo. Secretary, H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown.

Oct. 18–21—Southwest Section at Rice Hotel, Houston. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal

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Coming Meetings

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Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 22–24—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1.

Oct. 27–30—California Section at Palace Hotel, San Francisco. Secretary, John C. Luthin, 113 Laurent St., Santa Cruz.

Oct. 28–30—Chesapeake Section at Hotel DuPont, Wilmington, Del. Secretary, Carl J. Lauter, 6955—33rd St., Washington 15, D.C.

Nov. 4–6—Virginia Section at Roanoke Hotel, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Co., Inc., 915 Colonial-American Bank Bldg., Roanoke 11.

Nov. 9–11—North Carolina Section at Hotel Sheraton, High Point. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh.

OTHER ORGANIZATIONS

Sept. 28–30—New England Water Works Assn., Poland Spring House, Poland Spring, Me. Details from Joseph C. Knox, Secy., 73 Tremont St., Boston 8, Mass.

Oct. 8–9—National Conference on Industrial Hydraulics, Sheraton Hotel, Chicago. Details from Otmar E. Teichman, Conference Director, Illinois Inst. of Technology, 35 W. 33rd St., Chicago 16, Ill.

Oct. 13–16—Federation of Sewage and Industrial Wastes Assns., Municipal Auditorium, Miami, Fla. Details from W. H. Wisely, 325 Illinois Bldg., Champaign, Ill.

Oct. 26–29—American Public Works Assn., New Orleans, La. Details from D. F. Herrick, Exec. Secy., 1313 E. 60th St., Chicago 37, Ill.

Oct. 27–30—National Water Well Assn. at Hotel Benjamin Franklin, Philadelphia, Pa. Details from Robert R. Storm, Exec. Secy., 811 W. Springfield, Champaign, Ill.

Nov. 8–11—National Inst. of Governmental Purchasing at Netherlands Plaza, Cincinnati, Ohio. Details from Albert H. Hall, Exec. Director, 730 Jackson Pl., N.W., Washington 6, D.C.

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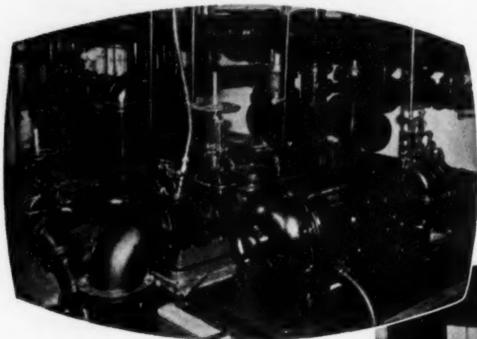

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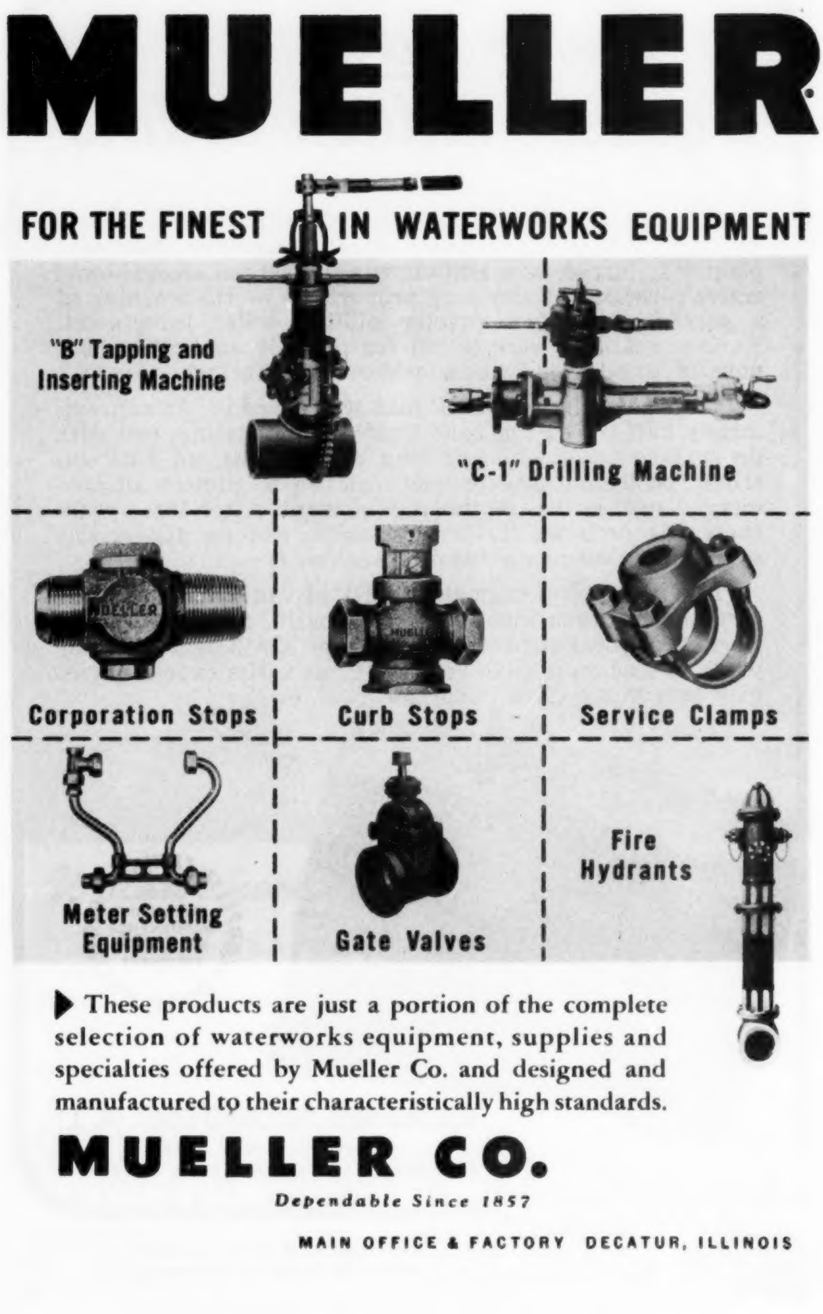
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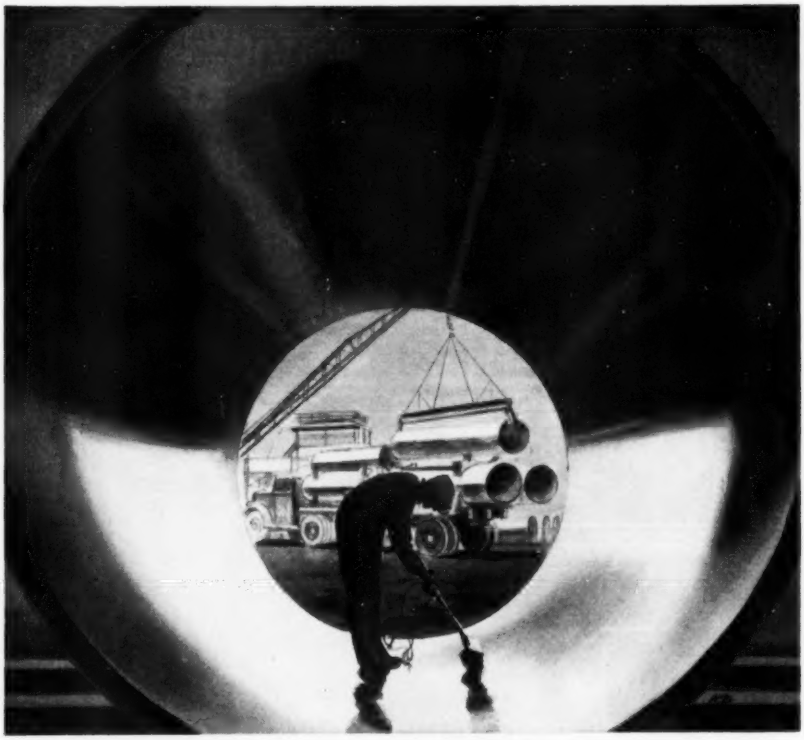

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 45 • JULY 1953 • NO. 7

Management of Missouri Basin Projects

By Dale L. Maffitt

A paper presented on May 13, 1953, at the Annual Conference, Grand Rapids, Mich., by Dale L. Maffitt, Gen. Mgr., Des Moines Water Works, Des Moines, Iowa.

ONE of the major internal problems facing the nation today is the need to determine the best long-range plan for the management of its great river basins. Literally hundreds of pamphlets, papers, brochures, and books have been written on this subject. Publicity through newspaper and magazine articles, particularly after the major flood in 1951, brought the matter before the public more forcibly than ever in the past.

Proponents of an all-powerful central government have used the geographical immensity of the basins as a reason to further their cause; they have been opposed energetically by those who defend the rights of the sovereign states. Powerful departments of the federal government have vied for basin control to such an extent that Congress itself has, on occasion, been required to act practically as an arbitrator. Billions of tax funds have been spent.

Through it all, the American public has been a somewhat confused witness. This problem cannot be solved by this or the next generation. No two basins are alike, and the technical details involve complexities that tax the understanding of the finest experts.

As the population grows, however, it becomes increasingly apparent that upon this generation rests the responsibility of determining broad policy for the conservation of the assets of these great basins and for their development in the interest of every American.

Some have talked of a Missouri Valley authority patterned after the Tennessee Valley Authority. The Hoover Commission included its recommendations on basin development in a report to the President in 1949. In 1950 the President's Water Resources Policy Commission made a detailed study and a three-volume report on national water policy. In 1951 the Engineers Joint

Council made a task group study of water resources development and published a set of principles for a sound national water policy (*1*). In 1952 the Missouri Basin Inter-Agency Committee and the Missouri River States Committee published a brochure (*2*) describing the program being carried forward by the various agencies active in the basin. Also in 1952 the Missouri River States Committee asked the Council of State Governments, Chicago, to prepare a compact that might serve as a basis for management of the completed projects.

All of these documents outlined recommendations for managing the projects, but they were not in agreement, for easily understandable reasons. The water and land resources development program in the Missouri River Basin it the largest undertaking of its kind in history. Federal agencies and the states in the area have joined to improve the watershed lands of the nation's longest river, to provide multiple direct benefits to the people in this agricultural center of the country and hoped-for indirect benefits to the rest of the United States.

The program, as presently envisioned, involves construction of multipurpose reservoirs, irrigation of millions of acres of land, navigation improvements, hydroelectric plants, control of floods, and other related activities. The costs of the scheme as now conceived are estimated at more than 11.2 billion dollars. It is understandable that estimates have increased each year as construction costs have continued to rise, even though the program may be proceeding, in general, according to the original plan.

The largest project completed to date is the Fort Peck Dam in northeastern Montana. In the first 11 years of operation, its sponsors estimate that it has averted $51,000,000 in flood damage. Although transmission facilities are not complete, electric power generated since 1943 is reported to have grossed $5,000,000 up to June 30, 1950. The hydroelectric installation will have a maximum capacity of 185,000 kw at times of ample water. Fish and wildlife resources at the reservoir have increased in importance.

Overlapping Interests

In 1884 the federal government established the Missouri River Commission for the improvement of navigation, and in 1902 this work was assigned to the U.S. Army Corps of Engineers. Activity in the nineteenth and early twentieth centuries was confined to scattered regulation work, removal of snags, and the building of navigation structures on certain streams.

Irrigation practices on the western tributaries date back to 1860. Early projects consisted merely of small ditches leading from streams to easily accessible tracts of land. As projects became larger and extended farther from the source of supply, cooperative organizations were formed. In 1903 the U.S. Bureau of Reclamation received authorization for the first federal irrigation projects in this region.

The Corps of Engineers was made responsible for river and harbor work in the United States in 1824, but it was not until 1929 that the agency made comprehensive studies of the Missouri River watershed. These studies formed a basis for later, more detailed, investigation and planning. The Corps of Engineers had no authority to construct flood control works in the basin prior to the passage of the Flood Control Act of 1936.

From the late 1930's to 1944 the Bureau of Reclamation also developed a coordinated plan for full use of the Missouri waters, to provide irrigation in the semiarid states of the upper basin and flood control and navigation in the lower basin, as well as power and other benefits.

It was becoming apparent that there was an overlapping of interests among the various agencies. The need for a coordinating body was evident, and the Missouri River States Committee was conceived in the early 1940's. Resolutions later adopted by this committee paved the way for merging the Missouri Basin development plans of the Corps of Engineers and the Bureau of Reclamation into the comprehensive "Pick-Sloan Plan" authorized by Congress in the Flood Control Act of 1944. This bill recognized the rights of the states in determining the development of watersheds within their borders, as well as their rights in water utilization and control. The committee, made up of ten state governors and their appointed representatives, has continued its active interest in the project.

Interagency Committee

In authorizing the Flood Control Act of 1944, Congress assumed that the federal agencies designated to carry out the plan would voluntarily work together. To further this end, the Missouri Basin Inter-Agency Committee was established in April 1945. The interagency committee is not set up by law and exercises no administrative controls. It relies for its effectiveness on the determination of its member agencies, both federal and state, to work toward a common goal. Since January 1952 the governors of all ten basin states have been official members of the committee. Federal members represent the Dept. of Interior, Corps of Engineers, Dept. of Agriculture, Federal Power Commission, Dept. of Commerce (added in 1947) and Public Health Service (added in 1951). The committee held its first meeting July 19, 1945, in Omaha, Neb. It now meets almost every month with the site rotating among the basin states.

An effective procedure used to guide the timing of related work in the basin area has been the compilation of a series of reports, known as the "Six-Year Program," prepared by a subcommittee of the interagency committee. These reports, listing individual projects, expenditures to date, expenditures required over a succeeding 6-year period, and the total funds needed to complete the work, have, for the first time, crystallized an awareness of the interrelated problems involved. Publication of the reports has entailed projections of estimates into an uncertain future. Rates of progress may be changed by national defense requirements. This uncertainty does not invalidate the ultimate objectives of the program but makes constant rescheduling necessary.

Although without legal status, the interagency committee and the Missouri River States Committee have made a studied effort to keep the public informed of the many details of the program, the progress being made, and the problems of coordination continually arising.

Studies on Coordination

The first steps and the final authority for coordination of the basin program rest with Congress and the state legislatures. Administrative coordination can proceed only within the limits of authority established by law and the appropriations that permit each phase to be inaugurated in proper sequence.

The various commissions and committees that have studied this problem seem fairly united in the opinion that a valley authority, as advocated by former President Truman and modeled after the Tennessee Valley Authority, is not the solution. It should be noted that almost all of the proposals suggested call for a "commission" as the managing body. The important point to keep in mind is the method by which a commission would be activated.

Hoover Commission

First, the Hoover Commission, in its report to Congress in 1949, presented a separate report on natural resources (*3*) and recommended the "Establishment of a consolidated Water Department Service, to administer the present functions of the Bureau of Reclamation, the river development functions of the Corps of Engineers, the power-marketing functions of the Bonneville and Southwestern Power Administrations and of the Division of Power in the Department of the Interior, certain river development functions now administered by the Federal Power Commission, and certain functions of the Department of State relating to international boundary streams." The report recommended the retention of the Tennessee Valley Authority in its present form, but the establishment of additional valley authorities was opposed.

Resources Policy Commission

In December 1950 the President's Water Resources Policy Commission made an extensive report (*4*), in which it stated that, lacking such an agency as was recommended by the Hoover Commission, "Congress should set up a separate river basin commission for each of the major basins. These commissions, set up on a representative basis, should be authorized to coordinate the surveys, construction activities, and operations of the federal agencies in the several basins, under the guidance of independent chairmen appointed by the President and with the participation of state agencies in the planning process. . . . Congress should designate the federal departments and independent agencies to participate in the river basin commissions."

Engineers Joint Council task groups, composed of men with long experience in water resources development, reviewed this commission report and found it, in general, incompatible with their own recommendations. The council's critique (*5*) of the report recorded "distinct disagreement with a series of proposals for implementation which appear to violate completely the sound principles acclaimed." Despite some references to local and state participation, the emphasis of the commission report seemed to be on federal direction and control. The separate basin commissions proposed would have the character of authorities, entirely independent of local and state governments. In another publication (*1*), the Engineers Joint Council recommended cooperative methods under the present form of representative government.

Survey Commission

Following the major flood of 1951, the President, by an executive order of Jan. 3, 1952, established the Missouri Basin Survey Commission to "study the land and water resources of the Missouri River basin and such other related matters" as the commission might deem appropriate; and to "prepare recommendations with respect to an integrated and comprehensive program of development, use, and protection of said resources."

The survey commission reported to President Truman Jan. 12, 1953, and its report (*6*) was released for publication Feb. 20, 1953. The eleven members were unanimous in agreeing upon the need for a central organization to direct and coordinate the development of land and water resources in the basin. Approved by an eight to three vote was "the creation of a Missouri Basin Commission composed of five members appointed by the President with the consent of the Senate," with recommendations for membership to be submitted by governors, legislatures, public and private organizations, and individual citizens of the basin area; the principal offices of the commission were to be located within the basin. In order that the states might have a voice in the establishment of the commission, any state could decline, by legislative action, to consent to the operation of the commission therein. The survey commission specified that the proposed commission would not be a Missouri Valley authority and would not replace existing agencies, nor would it assume full and complete authority over every phase of federal activity in the basin.

The three members dissenting from the view that the Missouri Basin Commission should be a federal instrumentality favored "an organization created by an interstate compact to which the United States and the Missouri Basin States, or such of them as ratified the compact, would be parties."

Early in 1953 an unofficial committee of members of the American Society of Civil Engineers, undertook to inform the members of Congress of the work that had been done by the Engineers Joint Council, with a view to placing before Congress the council's national water policy recommendations. These recommendations, it will be recalled, are materially at variance with former President Truman's Water Resources Policy Commission report, which may or may not now be officially recommended to Congress. President Eisenhower has made no commitments on the proposed federal commission.

Missouri Basin Compact

The Missouri Basin Inter-Agency Committee and the Missouri River States Committee, which are presently the coordinating agencies in the basin, recognized as early as 1949 that the facilities of the basin projects were rapidly entering the operational stage and that it would be desirable to have an overall body to direct the operation of the completed projects. The members of both committees were agreed that the public should be made to realize the problems involved in the various proposals for Missouri basin development and management. It was felt that citizens in the basin area would not favor a Missouri Valley authority if they were fully informed of the dangers involved, but would prefer a plan of operation that would preserve democratic control in the hands of the people most vitally concerned.

With the aid of the Council of State Governments, a proposed Missouri River Basin compact was prepared, a revised draft being published in January 1953 "at the request of Governor Sigurd Anderson of South Dakota, Chairman of the Missouri River States Committee, in order that further study and consideration may be given to use of the compact approach in the Basin's development" (*7*).

A prefatory statement explains the purposes of the compact:

It appears that effective development of the Basin's water and land resources

requires a new type of regional organization, one which is tailored to fit the Basin's special needs. Such a regional organization for the Missouri Basin, it is believed, should: [1] assure a high degree of Basin-wide coordination; [2] provide for effective participation both by the states of the region and by the national government in the formulation of basic, broad policy; and [3] utilize established governmental agencies in the construction of facilities and in the operation of programs.

The suggested Missouri Basin Compact is an interstate compact among the signatory states, and between the states and the national government. . . .

The compact would create a joint agency of the participating governments, the "Missouri Basin Commission." The "commission" is not intended to displace existing agencies, nor is it an "authority." Basically, the commission's powers would be recommendatory only, "but the official character of the body as an organic agency of the Basin's states and of the national government will endow its recommendations with considerable weight." The Missouri River States Committee feels that the compact offers a solution that is definitely worth considering.

It should be emphasized that the problem of managing the Missouri River projects is one of great importance to the inhabitants and industries in the basin, as well as to the country as a whole. The policy of management evolved for this area may establish a pattern for the operation of other river developments throughout the United States. Whatever method is adopted, however, the principles of democratic, representative government must, by all means, be maintained.

References

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2. The Missouri River Basin Development Program. Missouri Basin Inter-Agency Committee and Missouri River States Committee. U.S. Govt. Printing Office, Washington, D.C. (1952).
3. Organization and Policy in the Field of Natural Resources. A Report With Recommendations Prepared for the Commission on Organization of the Executive Branch of the Government. U.S. Govt. Printing Office, Washington, D.C. (1949).
4. PRESIDENT'S WATER RESOURCES POLICY COMMISSION. A Water Policy for the American People. U.S. Govt. Printing Office, Washington, D.C. (1950); *Jour. AWWA,* **43**:91 (Feb. 1951).
5. A Critique of the Report of the President's Water Resources Policy Commission. Engrs. Joint Council, New York (1951).
6. MISSOURI BASIN SURVEY COMMISSION. Missouri: Land and Water. U.S. Govt. Printing Office, Washington, D.C. (1953).
7. Missouri River Basin Compact. Council of State Governments, Chicago (1953).

Flood Protection in the Kansas River Basin

By N. T. Veatch, Louis R. Howson, and Abel Wolman

A paper presented on May 13, 1953, at the Annual Conference, Grand Rapids, Mich., by N. T. Veatch, Black & Veatch, Kansas City, Mo.; Louis R. Howson, Partner, Alvord, Burdick & Howson, Chicago; and Abel Wolman, Prof. of San. Eng., Johns Hopkins Univ., Baltimore, Md.

ON Sept. 20, 1952, the Kansas Industrial Development Commission engaged the services of a board of engineers, consisting of the authors, to review and analyze plans for the reduction of flood discharges in the Kansas River Basin, as promulgated by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the U.S. Dept. of Agriculture; the board was also authorized to prepare and submit flood protection plans for engineering and economic consideration.

In compliance with an agreement made at the time the contract was signed, the board, on Feb. 16, 1953, presented to the Kansas Industrial Development Commission a preliminary report setting forth tentative conclusions concerning the various plans for flood control in this basin, and proposing an alternative plan for protecting the urban areas from flood damage. The board's final report was submitted to the commission in June 1953.

The board reviewed the combined plans of the Corps of Engineers and the Bureau of Reclamation, transmitted to Congress on June 21, 1950, and sometimes referred to as the "Pick-Sloan Plan"; the enlarged reservoir program proposed by the Corps of Engineers subsequent to the 1951 Kansas flood and now called the "basic reservoir program"; and the "watershed treatment program" of the Dept. of Agriculture. In order to analyze and evaluate the effects of these various plans it was necessary for the board to obtain engineering data from the several government agencies involved. In the main, the board received excellent cooperation from these agencies.

The Pick-Sloan Plan as proposed prior to the 1951 flood included a total of eighteen reservoirs, five of which were then completed, and sixteen local-protection levee projects. The total estimated cost of this program was approximately $400,000,000.

The current reservoir program, greatly enlarged since the flood, comprises a total of 34 reservoirs and provides increased flood storage capacities in several of those included in the Pick-Sloan Plan. The cost of this enlarged program is estimated at $700,000,000. A further expansion of the reservoir program is indicated, with 84 additional reservoirs being studied. Although estimates of the cost of these additional units have not been made available to the board, it is believed that the total cost of the overall program will be at least $1,000,000,000.

The watershed treatment program of the Dept. of Agriculture is now before Congress. This plan, which, as far as

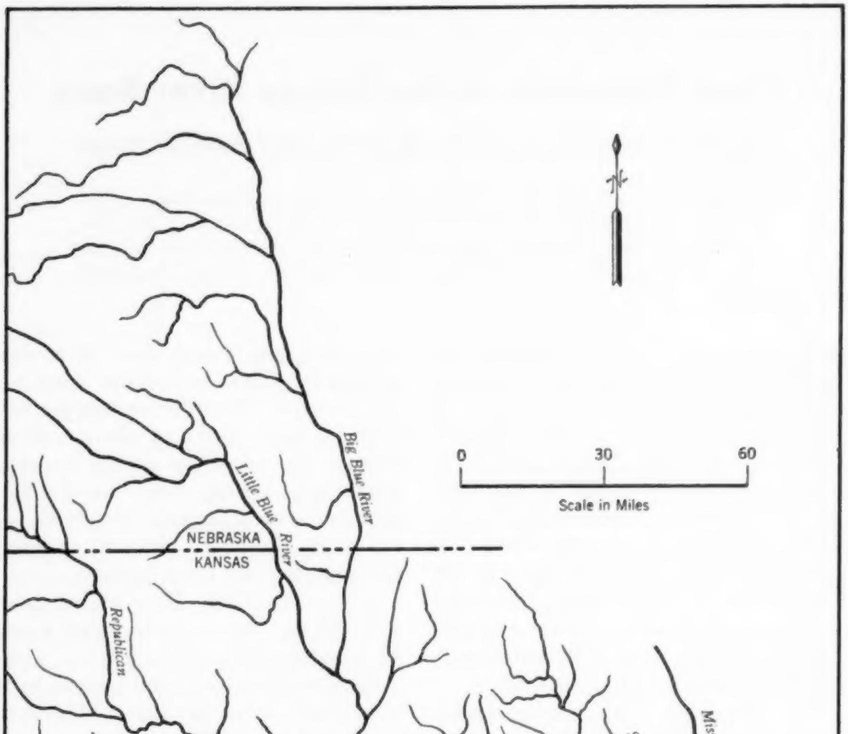

Fig. 1. Eastern Kansas

the Kansas River Basin is concerned, applies to the Big Blue Basin only, includes conservation and improvement measures for crop and grass lands, farm wood lots and shelter belts, measures for stabilizing small watercourses, upstream floodwater-retarding structures, diversion dams and ditches, floodways, technical and educational assistance, and research and soil surveys. The estimated cost of this program, which is said to be set up for completion in a period of 20 years, is $93,894,000. The number of upstream floodwater-retarding structures included is 912.

Appraisal of Programs

In assessing the effects of the several plans on the reduction of maximum flood discharges and stages in the valley below Manhattan, Kan., consideration may be given to a public statement made by the then chief of engineers in Kansas City, Mo., in July 1951: ". . . if we had had Milford and Tuttle Creek reservoirs, we could have passed this flood by Manhattan and Topeka. If we had had Milford, Tuttle Creek, and Perry, we could have passed it by Lawrence, and with these three, plus the existing levee system at Greater Kansas City, the disaster here would have been averted" (*1*).

Contrary to this statement, the district engineer at Kansas City, in a presentation before the Missouri Basin Inter-Agency Committee at Topeka, Kan., on Dec. 14, 1951, said that, if the authorized and recommended works (the Pick-Sloan Plan) had been in place during the 1951 flood, the recommended works at Manhattan would have been overtopped by 2–3 ft, those at Topeka by 1 ft, and those at Lawrence by 3 ft, and river stages would have reached the top of the existing and recommended works along the Kansas River in Kansas City. In fact, the local protection works along the Kansas River at Kansas City, which were designed to handle a flow of 260,000 cfs, the maximum flow of the 1903 flood, were topped at a flow of 262,000 cfs.

Data supplied to the board by the district engineer at Kansas City indicate that the maximum discharges during the 1951 flood, as reduced by the operation of the eighteen-reservoir program, would have resulted in stage reductions below 1951 crests of 2.2 ft at Wamego, 2.4 ft at Topeka, and 4.6 ft at Bonner Springs. Even with these reductions, the valley would have been inundated to depths of 9.4, 12.9, and 13.0 ft, respectively, at these points. These depths are approximately 1 ft less than the corresponding 1903 flood depths at these points.

Similar data indicate that the maximum discharges during the 1951 flood, as reduced by the operation of the 34-reservoir program, would have resulted in stage reductions below 1951 crests of 4.4 ft at Wamego, 4.9 ft at Topeka, and 10.4 ft at Bonner Springs. With these reductions, the valley would still have been inundated to depths of 7.2, 10.4, and 7.2 ft, respectively, at these points. Compared with 1903, these depths are 3.1 ft less at Wamego and 1.3 ft less at Topeka.

From a study of these data, which represent theoretically perfect operation, the board has concluded that neither of the reservoir plans proposed can be operated to prevent the inundation of a large part of the valley area during great floods such as those of 1903 and 1951.

Appraisal of the program of the Dept. of Agriculture in the field of

watershed management and treatment is difficult, because the detailed plan presented to Congress covers the Big Blue River Basin only, which comprises approximately one-sixth of the total area of the Kansas River Basin. Although the board strongly endorses the principle of soil conservation and believes that the economic losses due to soil erosion in parts of the Kansas River Basin may be much greater than those caused by floods, it considers that watershed treatment programs will have only minor effects on maximum discharges in the main streams during disastrous floods. Apparently this view is shared by the principal officers of the department.

It must be recognized that a long period will be required for the completion of a vast reservoir program in the Kansas Basin, which, as now envisioned, may include as many as 118 units. Prior to the 1951 flood the present Missouri River division engineer stated publicly that the completion of the eighteen-reservoir plan would require approximately 25 years. On that basis, the completion of the overall program could easily take as long as 50 years, or even longer. The program of the Dept. of Agriculture for the Big Blue River Basin only is set up for completion in a period of 20 years. The valley of the Kansas River has been subjected to two devastating floods in approximately 50 years. If adequate flood protection in this valley is to depend on either the reservoir plan or the watershed treatment plan, the region can expect to be subjected to such a flood again before either plan can be carried out. Although a repetition of the 1951 flood may perhaps be unlikely for hundreds of years, there can be no assurance that it will not occur at any time.

Flood Damage

Estimates of damage resulting from the 1951 flood, made by the Corps of Engineers (*2, 3*), total approximately $725,000,000 for the Kansas River Basin. Of this amount, the damage in urban areas was approximately $552,000,000, or 76 per cent of the total; and that in rural areas came to $173,000,000, or 24 per cent of the total. The total flood damage in the Kansas City metropolitan area alone was $478,052,800. Over the 50-year period from 1903 through 1952 the estimated average annual flood damage (including 1951) in the urban areas was $12,500,000, while that in the rural areas was approximately $6,000,000. Thus, the average annual urban damage was more than twice the average annual rural damage.

Kansas State College, Manhattan, Kan., made a soil survey of the entire flood plain area north of the Kansas River from St. George to Mud Creek (east of Lawrence), to determine the extent of soil damage resulting from the 1951 inundation. The field work for this survey was completed in December 1952, and analysis of the findings is now in progress. Results to date indicate that 72.6 per cent of the acreage flooded was actually improved in fertility, 13.6 per cent was neither improved nor damaged, 6.8 per cent was slightly damaged, and only 7 per cent was materially damaged. Manifestly, great losses to crops, farm buildings, and machinery do occur in the major floods, but actual damage to the land itself is apparently not as extensive as may have been supposed. Inundation from minor floods has given the valley land its high productive capacity and high values.

Because a large proportion of the economic losses resulting from major floods in the Kansas River Basin occurs in the urban areas, the board has concluded that any acceptable program for the reduction of such losses must be focused primarily upon these areas and that the protection of agricultural lands can be recommended only where it is economically justified by the benefits to be secured.

Board Program

The board considers that, although the proposed reservoir plan for flood protection might be operated to prevent the inundation of farm lands in the valley during the frequent minor floods, the expenditure involved cannot be justified, particularly as the benefits from these minor floods exceed the damage. The proposed system of reservoirs will not prevent the inundation of vast areas of the valley during flood periods following storms like those of 1903 and 1951, and it is such floods that cause great losses in buildings, machinery, livestock, and even human lives. Also, there is no precedent for the successful functioning of such a far-flung system of flood control reservoirs. The multireservoir system of flood protection has proved successful in relatively small drainage basins where the reservoirs are located close to the property to be protected and where adequate channels or flowways are provided below them. One such instance is the Miami Conservancy Dist. in Ohio, where the total basin area above Dayton is only 2,600 sq miles. Of the four reservoirs or retarding basins above that city, the most remote is less than 35 miles away.

For any such widely scattered system of reservoirs in a large drainage basin of 60,000 sq miles to be successful in controlling stream flow in the main stem at all times, the reservoirs must be so situated that there will be essentially adequate storage capacity downstream from any major storm center, regardless of its location; the entire flood storage capacity must be available at the beginning of each flood runoff period; and the rates of release of water from these reservoirs must be so controlled that the combined releases will not create flood conditions in the channels downstream. It is believed humanly impossible to operate a far-flung system of dams, during a major flood in the Kansas River Basin, in such a manner as even to approach the results that may be theoretically attainable. There was difficulty, for example, even in forecasting flood stages accurately at Kansas City during the 1951 flood.

For all of these reasons, the board has developed an alternative program that would guarantee protection to the urban areas against the maximum flow of the 1951 flood period; that would require the taking of land only in those areas which are to be protected; that would operate under all conditions of flood runoff, regardless of the location, configuration, intensity, or duration of any flood-producing storm within the basin equal to the 1951 storm; and that can be constructed within a reasonable time and at a cost substantially less than the probable cost of the reservoir program.

The only type of protective works that meets these criteria consists of enlarged channels or flowways and levees in the urban areas designed to carry the peak flow of the 1951 flood. Therefore, the board has devoted its activities to developing such a program. The recommended plan includes: the en-

larging of the present river channel through Kansas City, Topeka, and Manhattan; the construction of a cut-off channel and levee system at Salina; and the building of local levee systems to enclose low areas at Lawrence, Perry, Silver Lake, Rossville, St. Marys, Belvue, Ogden, Junction City, Chapman, Abilene, Enterprise, Solomon, Lindsborg, Marquette, Clay Center, Concordia, Frankfort, Waterville, Blue Rapids, Marysville, and approximately 20 smaller towns in the flood plains of the Kansas River and its principal tributaries.

At Kansas City, it is proposed to provide flowway capacity sufficient to carry the maximum flow of the 1951 flood (512,000 cfs), with a freeboard of 3 ft above the hydraulic gradient, by setting back the levees, principally along the left bank, to secure a nominal channel width of 1,500 ft, with transition sections increasing to 2,000 ft at upstream and downstream ends. Excavation within the new levee lines would vary from el 735 to el 746.5, with no excavation planned in the low-water channel. The plan includes the lengthening and raising of railroad and other bridges where required; the reconstruction of railroad tracks and signal equipment displaced by the channel-widening project; the revision of utility facilities, including electricity, gas, water, communications, street railway, sewers, and storm drains; and the acquisition of real estate and structures within the new levee lines. The design criteria for the recommended channel or flowway are based on the 1951 flood, instead of on the 1903 flood as in the existing levee system.

Details of the proposed flowways through Topeka and Manhattan follow, in general, the plan of design for the Kansas City flowway, as do the local protective works planned for the several urban centers on the main stem and its principal tributaries. In the board's opinion, $200,000,000 is a realistic estimate of the cost of the proposed flowway program.

Advantages and Objections

There are at least five obvious advantages to this program:

1. With the planned flowways and local protection projects completed, flood flows somewhat greater than those of July 1951 and, of course, all lesser flows would pass safely through the valley without damage to the urban areas.

2. The operation of the planned flowway system would not be dependent upon human ability to foresee the location, intensity, configuration, and duration of flood-producing storms throughout a watershed of 60,000 sq miles.

3. Real property required for the sites of flowways, flood walls, and levees would be located in the benefited areas rather than in remote agricultural areas that would receive no benefits. It is believed that an adequate reservoir program would necessitate the acquisition of approximately 450,000 acres of land in the Kansas Basin and the displacement of 1,500 families. The area of farm land in the Basin inundated in the 1951 flood was approximately 1,000,000 acres.

4. The recommended program could be completed and protection from inundation made available to the urban centers throughout the flood plain within a reasonable period.

5. The cost of the recommended program would be no more than 25 per

cent of the probable ultimate expenditure required for the completion of the combined reservoir and local protection programs as now envisioned. This saving would amount to $650,000,000 or more.

A number of objections have been advanced in opposition to the proposed flowway program:

1. The velocities of flow through the proposed flowway in Kansas City might be excessive during the period of maximum discharge and cause great damage to structures, such as bridge piers, in the channel, as well as to the levees and walls enclosing the flowway. In answer to the objection, it may be stated that measurements taken by the U.S. Geological Survey on July 14, 1951, at the James Street Bridge in Kansas City showed an average velocity of 14.62 fps in the channel section, and a top velocity of 17.8 fps near one of the piers. At the time of these measurements, the river was within ½ ft of the crest stage, the computed discharge of the river was 503,000 cfs and the computed discharge through the bridge opening was 421,000 cfs. No reports that piers supporting this bridge were damaged by high velocities of flow have come to the board's attention. In the proposed flowway, the mean velocity at this bridge, when the discharge through the bridge opening reaches 512,000 cfs, will be 8.76 fps, compared to the actual mean velocity of 14.62 fps at this section in the July 1951 flood. Further upstream—say, at the Kansas City Terminal Bridge—the mean velocity in the proposed flowway, when the discharge rate is 512,000 cfs, will be 10.1 fps.

2. The force of the current emerging from the mouth of the Kansas River into the Missouri, when the discharge rate in the former is as high as 500,000 cfs, might constitute a grave menace to the security of the levee at the municipal airport because of the configuration of the channels of the two rivers at their confluence. In answer to this objection, the widening of the Kansas River at its mouth, as proposed in the flowway plan, will materially improve flow conditions in the Missouri just below the confluence; the reduction in flow velocities in the Kansas, by reason of the enlarged dimensions of the proposed flowway, will greatly diminish the force of the outflow from this stream at high stages.

3. The security of the levees along the Missouri in the Kansas City area below the mouth of the Kansas might be endangered by discharging from the latter a flow as great as the crest flow during the July 1951 flood. In answer to this point, it is, of course, an indisputable fact that the crest flow of the Kansas was discharged into the Missouri during the 1951 flood and that none of the land protected by levees downstream from the Hannibal Bridge (approximately 1 mile below the confluence) was inundated by the overtopping of levees along the Missouri. According to statements made in the Corps of Engineers report (*3*), the North Kansas City area and the northeast industrial district sustained some damage due to seepage and trapped local drainage behind the levees. The maximum stage reached at the Hannibal Bridge in the 1951 flood was 36.2 ft, which indicates that the water elevation at the crest was 751.99. Construction plans show that present levees at this point provide more than 6 ft of freeboard above the 1951 crest elevation, so that there would be no imminent hazard of overtopping.

4. The plan makes no provision for the reduction of flood discharges from the Kansas into the Missouri, thus accomplishing nothing toward decreasing damage in the Missouri River flood plain below Kansas City and in the Mississippi River flood plain below St. Louis, Mo. In answer, it has been assumed that all urban areas along the Missouri River from Kansas City to St. Louis would receive protection similar to that proposed for cities in Kansas. In fact, most of these urban areas are largely out of the flood plain. So far as the rural areas are concerned, there seems to be no reason why the same economic analysis that has been applied to the rural areas in Kansas should not apply equally well in Missouri. According to the Corps of Engineers, even if the so-called basic reservoir plan had been completed prior to the 1951 flood, the maximum flow at Kansas City would, in theory, have been reduced to 225,000 cfs, only 35,000 cfs less than the maximum discharge of the Kansas River in the 1903 flood. Consequently, the conditions along the Missouri would not have differed materially from those in 1903. As the proposed reservoir system could not, it is believed, be operated at theoretical efficiency, it would not significantly increase flood protection along the Missouri River from Kansas City to St. Louis. It might cause slight differences in flood crests but not enough to be of any practical importance.

5. The construction of a wider channel through Kansas City would entail a great deal of dredging. In answer to this point, it is certainly true that the levee slopes and the bottom of the flowway outside the low-water channel would require periodic maintenance work. Growths of vegetation would have to be cut, and stone levee facing or riprap would probably need some repair following high flood flows, as do the present channel and levee slopes. Because no deepening or widening of the low-water channel is proposed, however, dredging requirements there would be no greater than in the past. It is concluded, therefore, that any increase in maintenance costs would be relatively minor. Moreover, maintenance costs for an extensive system of reservoirs would probably be very much greater than those for the proposed flowway program.

6. There might be financial difficulties. In answer, it may be stated that, under the present flood control reservoir program, substantially all of the costs of financing are borne by the federal government, while the expense of levee and flood channel systems is borne in part by the federal government and in part by local bodies—cities or drainage districts. At present local funds are normally used for acquisition of the land necessary for a project, with actual construction paid for by the federal government.

The total cost of the proposed levee and flood channel system would be substantially less than that of the reservoir system, but the costs of acquiring the necessary land, particularly in the vicinity of large cities like Kansas City, might well be greater than can be financed by the local governing bodies under present legal limitations. Under these circumstances, it is believed that a portion of the land cost should be borne by the federal government, but it is also believed that local participation is sound in principle and should continue.

Both cities and drainage districts have authority to enter into agreements

with the federal government and to purchase the land required for flood protection works constructed by the latter. It is understood, however, that drainage districts, under the present law, are confined to comparatively small areas, and cities, of course, are also limited in area. In order that all who benefit directly or indirectly from a particular phase of the proposed levee and flood channel program may share its cost equally, it is suggested that consideration be given to the enactment of legislation permitting the organization of one or more large conservancy districts embracing a substantial portion of the valley of the Kansas River and adjacent territory dependent upon it.

This aspect of the question is beyond the scope of a purely engineering report. There should be little difficulty in financing the proposed levee and flood channel system, however, once it is adopted in principle and public bodies at all levels make a real effort to solve the problem. In comparison with the reservoir system, the recommended plan certainly represents a decided saving to the people as a whole and will eliminate the taking from productive use of great areas now contemplated for reservoir sites.

7. The recommended plan provides no protection from inundation for the rural areas. In answer to this objection, it may be pointed out that the reservoir program, as now defined, also does not provide such protection from floods of great magnitude. As previously mentioned, data supplied to the board by the Corps of Engineers indicate that, even with the 34-reservoir program in operation during the July 1951 flood period, the valley land, not protected by levees, would have been inundated to depths of 7–10 ft or more. If an expenditure of $850,000,000 is necessary for the reservoir program to protect all of the valley area, both rural and urban, and if ample protection of the urban areas can be obtained through the flowway program for $200,000,000, the difference, $650,000,000, would be spent for rural protection alone. Assuming that the area inundated by the 1951 flood, both in the Kansas Basin and in the Missouri Basin below Kansas City, was 1,500,000 acres, the cost per acre for protection of this area would be approximately $400. It is apparent that, if economy is to be considered at all, no such expenditure can be justified.

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Main Extension Policy at Grand Rapids

By Frederick Wegner

A paper presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by Frederick Wegner, formerly Admin. Asst., Office of City Mgr., Grand Rapids, Mich., and at present Village Mgr., Roseville, Mich.

EVERY large city sooner or later faces the problem of determining a satisfactory policy on how much service it will extend to surrounding areas and under what circumstances it will be rendered. Although there are many possible solutions to this problem, it is not the purpose of this paper to describe them all, but rather to relate the experience of Grand Rapids, Mich.

Grand Rapids at one time favored the sale of water to the surrounding townships on a wholesale basis; meters were installed at the city limits and the distribution system of the satellite community was its own responsibility. In the early 1940's, with the completion of the pipeline from Lake Michigan to Grand Rapids, the sale of water to surrounding areas was actively promoted. In 1943 the city adopted a policy of direct billing of all connections, including suburban. The changeover, which was completed in 1950, was, on the whole, well received. In general, the suburban water customers' bills have not increased materially. Although the townships still own their distribution systems, the city maintains them. The city has either installed its own meters or purchased already existing, customer-owned meters if they were in satisfactory condition.

The present policy of the city on replacement of suburban mains is that, where the pipelines originally installed are of steel, or of cast iron of a kind and size not in keeping with city standards, the outlying area will have to pay for the replacement. Just what the city will do when suburban mains of standard size and quality need replacement is a problem that has yet to be faced. It is likely that the replacement will be at city expense, because Grand Rapids' water rates include a readiness-to-serve charge for both outside-city and inside-city users. It is Grand Rapids policy to replace mains inside the city at city expense.

In 1950 Grand Rapids realized that its existing water supply would have to be enlarged if the fringe areas were to receive further extensions. The city is currently investigating ways and means to do so.

In the summer of 1952 the rates charged outlying users were raised from 110 to 160 per cent of urban rates. This increase was not an attempt to penalize the suburban customer but merely a reflection of the cost of service borne by the city water user indirectly. At first it appeared that the rate increase could not be imposed on the surrounding townships because they held 30-year contracts with the city. Fortunately, it was found that the city charter prohibited any contracts of more than 3 years' duration,

and a ruling of the city attorney freed Grand Rapids from their restrictions. This experience brings out one of the disadvantages of long-term fixed-rate contracts.

As a result of the increased rates, some of the surrounding townships are currently making investigations to develop their own sources of supply. No substantial extensions of services to the townships are being made by the city until it is assured that they want Grand Rapids water permanently.

"Urban Service Plan"

To supply the outlying areas with city water, if they do decide to take it on a permanent basis, a cooperative arrangement, called the "Urban Service Plan," is in the process of being worked out through the combined efforts of planning and administrative groups in both Grand Rapids and the townships. This plan is predicated on the principle that it is most economical to provide service to approximately 6,000 people per square mile, requiring approximately 15 miles of water mains. As a part of this program, the population trend was projected well into the future and a perimeter beyond which city utility services would not be extended was established. On this basis, it is possible to estimate the water supply necessary to service the metropolitan area in the foreseeable future.

The "Urban Service Plan" is unique in that it does for politically independent units what is elsewhere accomplished through annexation or the creation of a district. The plan is not limited to water supply but includes the extension of other utilities, as well as the treatment of subjects like zoning and public health.

The financing of water main extensions in suburban areas is, the author believes, very well handled under the plan. The city will not extend any mains until the area desiring the service furnishes all the money needed for construction. This proviso places the entire responsibility for financing upon the fringe area and gives the city complete freedom in furnishing the service. The city is not required to advance money that belongs to its citizens to do work for any other governmental agency. As can be readily appreciated, the plan eliminates all haggling and dickering.

Grand Rapids has a cast-iron distribution system, with 12-in. mains on section and quarter lines and at least 6-in. mains in the interior. These standards are also maintained outside the city. It is important for the municipality to guard against attempts by suburban users to persuade it to install smaller lines that will be detrimental to the distribution system. Where such lines were laid before Grand Rapids took control, the situation is being corrected.

Within the city, the cost of 12-in. mains is shared by the water works and the adjoining property owners. Although arrangements within townships may differ, Grand Rapids is paid in full for the cost of 12-in. mains installed in suburban areas. The actual installation, except for short sections, is made by private contractors under the supervision of the city engineer. All work is done on a competitive-bid basis, and all pipe and fittings are furnished by the city water works. Short extensions, 60–250 ft in length, are installed by water works crews in trenches dug and backfilled by the property owner under the supervision of the city engineer.

To install a 6-in. pipe, the city charges $3.50 per foot for the first 60 ft, and $3.00 per foot for the rest, up

to the maximum 250 ft. All taps on the distribution system are made by water works crews, and the city inspects all plumbing connections from the main to the meter and the meter setting.

Conclusion

The current policy of not making any large extensions until it is ascertained whether the outlying areas want city water permanently hinges on the fact that they use approximately 10 per cent of the total supply, an amount which, if available for city use, would provide an adequate safety margin. To meet peak demands, Grand Rapids has been forced to augment its lake supply with river water. The added 10 per cent used by fringe areas would enable the city to take care of its own present needs even in peak periods. If suburban areas desire city water service, however, the Grand Rapids policy will provide it in a satisfactory manner and at a price that is fair both to the outside user and to the city.

Revocation of CMP Regulations

On June 15, 1953, the National Production Authority announced the revocation, effective July 1, 1953, of Controlled Materials Plan Regulations 1, 3, 4, and 6 (including outstanding directives). This action completed the planned elimination of the basic CMP regulations. Beginning with the third quarter of 1953, the Defense Materials System regulations will become the federal government's basic mechanism for supporting the U.S. Dept. of Defense and Atomic Energy Commission programs.

The revoked CMP Regulation 6 has been the basic regulation governing most construction. Beginning July 1, 1953, it will be replaced by DMS Regulation 2, which applies only to construction for defense purposes.

Water Service for Suburban Areas

Committee Progress Report

A committee progress report presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by Lewis S. Finch, Chairman, Committee A3.D—Water Main Extension Policy; Vice-Pres. and Chief Engr., Indianapolis Water Co., Indianapolis, Ind. The other committee members were: E. F. Dandridge, H. R. Devilbiss, M. P. Hatcher, and C. M. Hoskinson.

THIS 1953 progress report of Committee A3.D—Water Main Extension Policy is devoted to the presentation of a comprehensive analysis of the problem of providing water service for suburban areas. In this analysis, there is included a discussion of: [1] alternative methods of providing suburban water service, [2] suburban water service rates, and [3] suburban main extension policies.

In developing this study, the committee has been working upon an assignment from the Committee on Water Works Administration to study the administrative "problems involved in the extension of water mains, both within and without the corporation limits, including a digest of enabling legislation." At the 1949 AWWA Conference, Committee A3.D presented a progress report (*1*) devoted largely to establishing general principles that could serve as a foundation upon which to base the details of procedure applicable to administering main extension policies. In the current report, the committee not only has applied these fundamental policies to the development of water service for areas beyond the corporation limits, but it also has reviewed the legal, financial, and civic aspects of the suburban water service problem as well. The committee, in attacking the suburban problem, did not at first plan to consider the legal and civic aspects. It soon found, however, that a proper suburban main extension program could not be developed unless those responsible had an understanding of the legal problems involved and, in addition, an appreciation of the hazards to the civic well-being of a community which could result from indiscriminate extension of water mains into outlying districts. Therefore, the committee broadened the scope of the study to include these factors. In addition, the report contains a discussion of the factors that should be incorporated in main extension rules, covering, where applicable, the problems arising when water service is extended into suburban areas. Inasmuch as it is impossible to develop proper financial control over water main extensions without an understanding of the relationship between rates and extension policies, the study was further broadened to include a review of the suburban rate problem.

Diversity of Policies

The committee compared the requirements and recommendations of

many of the state utility commissions and was struck by the lack of uniformity of the policies followed in controlling main extensions. This situation should be improved before very long, as a committee of the National Assn. of Railroad and Utility Commissioners (NARUC) is developing a set of uniform rules applicable to the operation of water utilities. These rules will contain a recommended standard practice with relation to main extensions, which will be offered for adoption by state regulatory bodies. It is anticipated that AWWA will be able to develop a working contact with the NARUC committee, so that the utility as well as the regulatory commission viewpoints may be incorporated in the NARUC report. It is hoped that the NARUC rules applicable to main extensions will serve to promote uniformity of requirements.

The diversity between rules being followed by water works utilities in providing for the extension of water service to suburban areas is clearly brought out in many very worth-while papers on suburban main extension problems published in the JOURNAL. A comprehensive paper dealing particularly with this question was presented in 1941 by M. B. Whitaker (*2*). In 1948 a valuable panel discussion (*3*) on "Service Extensions to Suburban Areas" was on the program at the AWWA Conference. Further references to papers dealing with the suburban problem which have been published in the JOURNAL are incorporated in the text of this report.

The Regional Plan Association, Inc., devoted its March 1952 bulletin (*4*) to a report of a survey of subdivision requirements of 95 communities in the New York metropolitan area. Sixty-seven per cent of these required that the developers install the water mains at their own expense, while 12 per cent of the municipalities themselves made the installations. Fire hydrants were studied separately, and it was found that, in 42 per cent of the communities studied, they were installed at the expense of the developers, with the municipalities installing the hydrants in 43 per cent.

In 1952 *Water Works Engineering* presented a round-table discussion (*5*) on "Selling Water to Outside Communities," in which many water works men briefly stated the practice followed by their utilities.

In a 1952 issue of the AWWA publication *Willing Water,* Virgil C. Knowles (*6*) told of his experiences in "Getting Along With a Boom Municipality." In this article, he explained how Sidney, Neb., solved the water main extension problem of subdivisions.

In this progress report, alternative methods of procedure will be discussed, but it is not within the scope of this study or the purview of the committee at this time to recommend a specific procedure or to express a preference for a particular method to be followed in developing suburban water service. Conditions and regulations vary so widely throughout the country that what is suitable in one community may be entirely unacceptable, or inapplicable, in another. Therefore, in this report the committee will limit its efforts to a discussion of the various factors involved. It is hoped that those faced with making decisions on the development of suburban water service may find the material to be both informative and provocative of further study.

Alternative Methods of Providing Suburban Water Service

It may prove best in one community for the utility serving the parent municipality to provide the needed suburban water service. In another locality, it may be preferable, either from the procurement standpoint or because of the financial factors involved, or for other good and sufficient reasons, to establish a metropolitan or even an independent suburban water utility.

Service From Urban Water Works

Consideration will first be given to some of the problems involved if the parent municipality decides that it would be in its best interest to provide water service for the suburban area. When this decision has been made, many fundamental questions immediately arise which must be answered before the promoting agency or the utility proceeds. Four of the more general of these fundamental questions are:

1. Is it legal for the utility involved to serve areas outside the municipality?
2. Is the utility obligated to serve suburban areas?
3. Is it feasible for the utility to extend service to suburban areas?
4. Is it desirable that the utility extend its service to suburban areas?

These questions will be discussed briefly.

1. *Is it legal for the utility involved to serve areas outside the municipality?*

The answer to this question depends largely upon local statutory provisions, upon charter or franchise restrictions, or upon limitations on the activities of the utility resulting from contractual relations with holders of outstanding bonds or other obligations.

In most localities, it is legal, if a surplus supply is available, for either a municipally or a privately owned utility to provide service beyond the city limits. The legal limitations in Kentucky may, in general, be considered typical of those prevailing in most, if not all, other states. B. E. Payne (*7*) has cited several relevant Kentucky court decisions involving publicly owned utilities:

a. A statute authorizing a city to provide [the city and the inhabitants thereof] with water and light does not prohibit the city from extending such service to points without the city limits, where it can do so with little additional expense and in such a way as to result in advantage to the city and its inhabitants. (*City of Henderson* v. *Young*, 119 Ky. 224, 835 S.W. 583.)

b. A city owning and operating water works may contract to supply water for use outside of the city, where there will be sufficient water remaining to supply the residents of the city. (*Rogers* v. *City of Wickliffe*, 29 Ky. Law Rep. 587, 94 S.W. 24.)

c. Where a city owns and operates its own electric light plant or its own water works, it may legally sell any excess of its product to outsiders, but it cannot acquire a franchise, by purchase or otherwise, in the absence of legislative authority, to operate a water works system in and for the benefit of another municipality. (*Dyer* v. *City of Newport*, 123 Ky. 203, 94 S.W. 25.)

From these examples and other references in the literature, it may be anticipated that, in most localities, it will be found legal for a municipally owned utility to serve customers beyond its corporate boundaries. Most privately owned utilities, in the absence of contrary charter provisions, franchise stipulations, public utility commission rulings, or conditions imposed in con-

nection with financial undertakings, likewise may legally offer service beyond the corporate limits of the municipality.

2. *Is the utility obligated to serve suburban areas?*

In general, it is unlikely that a utility owned by a municipality will be definitely obligated to serve areas outside its boundaries. In some states, however, it will be obligated to expand its suburban service if it already has extended service beyond its limits. Court decisions in Pennsylvania, for example, have indicated that, once a municipality starts serving a suburb, it generally is under obligation to continue to serve and to expand service in such areas. This matter was discussed by W. Victor Weir (*8*) in a paper published in 1952.

If a privately owned utility has never extended suburban service, whether or not extension beyond the city limits can be demanded depends largely upon local statutory or common law requirements. The duty to provide such service also depends upon commission requirements, charter provisions, established precedents, or other local circumstances. Suburban water service might, perhaps, be required if the suburban business could be shown to yield a proper rate of return to the parent utility and if it previously had extended service into suburban areas; the utility would be open to the charge of discrimination should it refuse other suburban extensions under similar circumstances. Conversely, a utility could not be required to extend its service if the financial return were not sufficient to support the necessary investment. To require otherwise would constitute confiscation.

For example, the Massachusetts Dept. of Public Utilities is prohibited from ordering a water main extension if it appears that compliance with the order would result in permanent financial loss to the corporation (Section 92, Chapter 164, and Section 2, Chapter 165, Massachusetts General Laws). The Massachusetts commission can and does issue orders for extensions on condition that the customer pay a sufficient part of the cost to prevent a permanent loss to the utility. The commission has stated further that it must protect existing customers as well as compel a company to make reasonable service extensions.

3. *Is it feasible for the utility to extend service to suburban areas?*

The feasibility of suburban service extensions depends upon a number of local factors. In the first place, the existing utility must have enough water to enable it to extend suburban service without jeopardizing the adequacy of the supply for the primary service area. This fact can only be determined by considering the growth trend of the community, the size of the available supply, and the capacity of the existing treatment works and other production or distribution facilities.

It obviously is quite important to take into account the practicability of extending relatively large feeder mains from the existing distribution system into the suburban areas. The cost of such extensions may be prohibitive if the distribution system has been developed in such a manner that only relatively small mains are within a reasonable distance of the city limits. Before committing itself to a policy of expansion, therefore, the parent utility must carefully consider whether the trunk mains that can be extended at reasonable cost will provide an adequate supply in the suburban area.

Topography must also be studied. The area in question may be so high above the primary pumping station that it will be necessary to install booster pumping stations, at a cost which cannot be met from suburban service revenue.

4. *Is it desirable that the utility extend its service to suburban areas?*

The question of the desirability of service extensions is again one which can be answered only after a careful study of local circumstances. Although no general rules can be laid down, it should be helpful to discuss certain factors.

It is of paramount importance to determine whether the suburban area really is in need of the service and, if the need exists, whether the suburbanites will make sufficient use of the service to warrant the expense of providing the necessary facilities.

Except in very unusual circumstances, water service should be extended to suburbs only when sufficient business can be obtained and when the revenue from the operation will be commensurate with the cost involved. A profit of the same order as, or even higher than, that derived from the sale of water within the city itself should be earned from the suburban business. It has been held by a superior court in Pennsylvania that a municipality serving its own customers without profit can charge suburban rates which will yield a profit (*8*). The municipality serving suburban areas falls essentially into the same category as a privately owned utility with respect to such business (*9, 10*).

Utility management should realize that, in suburban areas, the density of population most likely will be much lower than within the limits of the municipality itself and, consequently, that the cost of serving the same number of people in the suburbs will be considerably greater than within the city. This statement applies not only to the extension of water service but also to the installation of streets and sewers and the provision of fire protection, garbage collection, and other municipal services.

It is almost axiomatic that, if financial considerations are favorable to the utility, whatever is good for the city making up its primary service area will also be good for the utility. Conversely, whatever is detrimental to the city's best interests likewise will tend to be harmful to the utility. These principles broaden the field to be studied, as they encompass the interests of the entire community rather than those of the utility alone.

It should always be borne in mind that the extension of water service into suburban areas will probably tend to accelerate decentralization trends within the city. In aggravated instances, this may result in creation of blighted areas and stagnation of development in established business districts. Likewise, extension of water service into suburban areas often will retard the annexation of such areas to the parent city. Cities lose one of their main inducements to annexation if they allow indiscriminate extension of water service to suburban areas. As orderly annexation of territory is necessary to the growth of a city, this condition usually will be detrimental to the best interests of the municipality. That municipal officials are cognizant of such problems is evidenced by the following news item (*11*):

> The struggle between city and suburb touched Elyria, Ohio. The city council refused to sell water to two multimillion dollar shopping centers going up in

nearby Sheffield township. Reason: the council feared the competition would steal trade from Elyria stores. Moreover, it noted the shopping centers would pay Elyria no taxes.

Although it is well for municipal officials to attempt to control decentralization, it should be borne in mind that the orderly development of suburban areas is necessary to the continued growth of the central city.

It may be desirable to supply water to an industry that cannot, or will not, locate within the city but will provide employment for its citizens, give business to local establishments, and, incidentally, often create new water customers within the city. Water service should not, however, be extended on terms that may constitute a subsidy to the industry. For instance, at Sacramento, Calif., when a firm is located outside the city, it is the practice to require it to pay all water main extension charges without benefit of refunds. This may be an extreme example, but, in any event, the utility should not invest more in the extension than the revenue from the industry will warrant. If a community does decide that a suburban industry should be subsidized, it ought not to be at the expense of the water utility and its customers.

It likewise should be borne in mind that, if the city does not extend suburban water service, suburban development nevertheless may take place, either with the utilization of unsafe individual wells which constitute a health hazard to the entire community or with the development of independent water utilities which later may tend to discourage annexation more than would the extension of the municipal water system.

For the purpose of this study, let it be assumed that it would be legal and feasible, as well as desirable, to serve a suburban area from an existing water utility. The decision then to be made is whether the utility should develop a suburban distribution system itself or should encourage the development of independent suburban utilities, either publicly or privately owned, to which water would be sold on a contract basis through master meters.

In making this decision, it should be borne in mind that, even though the producing utility is municipally owned, a profit should accrue to it from the suburban operations, unless the city is so crowded that expansion into outlying areas must be encouraged. The fact should not be overlooked, however, that, in addition to earning a profit, the producing utility definitely would be assuming responsibility for providing adequate water service in the suburban district, unless it should attempt to disclaim such responsibility in accepting the business.

If the central utility extends its distribution system into outlying areas, it can be assured that the design of suburban feeder mains and distribution systems will be on a basis suitable for absorption into the municipal system should the area be annexed. If independent suburban utilities are allowed to develop in the fringe area, it is possible that, on annexing the area, the city would find itself in competition which it could have avoided by making its own extensions. Should it be forced to buy out the competing water works in the event of annexation, the utility might be required to take over the latter's obligations, which may have been based on ill-considered circumstances and issued on unfavorable terms. Therefore, if the central utility agrees to sell water through master meters to an independent suburban utility, a provision should

be incorporated in the contract making it possible for the producing utility to acquire the distributing agency on a reasonable basis whenever the suburban area is annexed. It also would be well to provide that the suburban mains should meet the design standards used in developing the municipal distribution system.

Grand Rapids Policy

A comprehensive analysis of the fringe problem and a thorough appraisal of several courses of action open to municipal officials in developing suburban areas have been made by Betty Tableman (*12, 13*), Research Assistant, Institute of Public Administration, University of Michigan, Ann Arbor, Mich. She reports that Grand Rapids, Mich., has an "urban service policy" which deserves careful study by those responsible for the development of a plan providing for the extension of facilities into suburban areas. The following quotation (*13*) is presented at length as it describes a course of action that has proved successful, under Grand Rapids conditions, in controlling such extensions:

> Although many cities have developed contractual arrangements for serving their incorporated suburbs and unincorporated fringe areas, perhaps the most carefully thought out "urban service policy" is that recently adopted by the city of Grand Rapids, Mich. Here the city decided that its primary goal was a sound metropolitan community and that it was in the city's best interest to service the fringe areas with water, sewerage, and fire protection. At the same time the city felt that fringe development should be orderly and controlled.
>
> Consequently, Grand Rapids has utilized its willingness to provide services as a means of securing zoning and subdivision controls in the areas served. First, the city through its planning commission made a careful study of the existing land use of the entire metropolitan area and the probable future land needs for the population growth anticipated in the next 20–30 years. Developable areas adjacent to areas which would have to be served in any case were carefully checked and their feasibility for development discussed with the Federal Housing Administration, mortgage and banking concerns, and the local governments involved.
>
> After this basic study, meetings were held with the governmental bodies of all the surrounding communities, under the auspices of the Metropolitan Grand Rapids Development Assn. As a consequence, agreement was achieved on a uniform declaration of policy. It covered the following points:
>
> 1. A definite service line was established beyond which neither the city nor those townships having facilities would extend water or sewerage service. [Comment by committee: water service has been extended beyond these limits, but on terms definitely less favorable than those offered within the metropolitan area.]
> 2. Beyond this line, uniform township zoning would require larger lots so as to forestall dense urban settlement. (The city suggested 1-acre zoning outside the service area, but the townships decided to adopt a ½-acre restriction.)
> 3. Uniform subdivision regulation would require minimum lot areas per family, with the minimum varying according to whether the lot is provided with both, either, or neither water and sewerage service.
> 4. All subdivision plats are to be submitted to the "service committee" of the city of Grand Rapids prior to official approval by other governmental units.

There are several aspects to the Grand Rapids experience which are worth noting. Grand Rapids has considered the metropolitan fringe problem its problem, and it has undertaken to solve it in terms

of the best interests of the area as a whole. The interests of the city and of the outlying sections were equally important in the determination of the urban service line. Nor has the service problem been solved in isolation; tied with zoning and subdivision control, the service arrangement should see to it that equally drastic problems do not arise on the periphery in future years.

The fringe problem has been licked, not by the city alone, nor by the fringe alone, but with the cooperation of all the governmental units involved, under the leadership of the city. In passing, it is interesting to note that at one time Grand Rapids seriously considered creation of a metropolitan special district. As it is, the Grand Rapids urban service policy is a significant development in the solution of the fringe problem, and one which other cities might well consider.

It would appear from the foregoing discussion that, if proper safeguards are established, it usually will be found desirable to provide suburban water service from urban water works.

Evaluation of Plans

The two main plans that may be followed in extending suburban water service and their principal advantages and disadvantages will now be discussed.

1. *City ownership of suburban mains and facilities.* This plan may be against the city's best interests in some respects, as leverage that can be used to force annexation will be lost under this scheme. Further, an almost limitless obligation will be placed on the city. On the other hand, with proper safeguards, there may be advantages. Distribution system extensions into suburban areas can be more closely integrated with the parent system so that, on annexation, the mains will have the proper characteristics. By limiting extensions to prescribed limits, fringe development may be controlled.

2. *Sale of water to a public agency or privately owned suburban utility.* It is difficult to make this plan serve the city in a way that is wholly satisfactory but it can be practicable if the following safeguards and checks are adopted and can be enforced:

a. Provision of a formula for purchase of the suburban facilities in the event of annexation. A prescription on covenants for bonds sold, particularly regarding call privileges, might even be included.

b. Limitation on the area served. It invariably will happen that someone will want service just across the line. Such demands may be met by supplemental contracts, but it will probably be better to preserve the rule. In the city's interest, the service area should not extend beyond the area that might be annexed.

c. Limitation on the quantity of water furnished, and

d. Limitation on the term of the contract. These two requirements should be considered together. It is the opinion of many that, if annexation is not to be discouraged, the maximum quantity of water supplied should be no more than will allow for normal growth during a short period, approximately 5 years or less. This may seem a harsh requirement and it may make the financing of the public agency extremely difficult or even impossible. But it is thought to be the key to the preservation of the city's opportunity to expand. The apparent harshness might be tempered by a provision that the quantity limitation would be subject to change if agreed to by supplemental contract at least 5 years in

advance of the effective date of the change. This arrangement would give the agency at least 5 years' notice if it had to look elsewhere for an increase in its water supply. The term of a contract including these provisions would be almost automatically fixed by them, but it might still be possible to combine a limited supply with a 20-year contract, for example, in a way that would allow for proper financing. Such provisions should be adopted only after careful study of their enforceability.

e. Limitation on the city's responsibility in the event of a water shortage. Kansas City has used this clause in many of its contracts:

> The city's first obligation is to its own citizens and water consumers in Kansas City. The city will undertake to deliver water to ———— in such quantities as required for use in areas described herein under the conditions and for the considerations stated herein. However, the city does not bind itself during periods of water shortage resulting from an emergency condition or an inadequacy of mains or other facilities to do more than deliver water to said metering stations in such quantities as are available for allocation by the city among all suburban consumers after the demands of water consumers and the demands for fire protection in Kansas City have been satisfied.

Should the utility serving the parent city refuse to extend its distribution system into suburban areas or offer to do it only upon impractical or prohibitive terms, it will be necessary for the suburbs to develop their own facilities. This can be done in various ways.

Independent Utilities or Districts

There are excellent examples of privately owned suburban water utilities that are providing proper, adequate and economical service to their customers. For instance, surrounding suburban areas are adequately served by the St. Louis County Water Co. and the Philadelphia Suburban Water Co. Other examples of highly successful privately owned suburban water utilities might be cited, indicating beyond a doubt that it is feasible and often desirable, under special conditions, to provide suburban water service in this manner.

If independent suburban water utilities are to be established, it must be decided whether they should develop their own supplies or purchase water from the parent municipality and distribute it to the suburban customers. The latter practice is followed in the suburban area about Kansas City, the supply being purchased from the municipally owned Kansas City, Mo., water works. The St. Louis County and Philadelphia suburban water companies have developed their own independent supplies.

Where statutory authority is available, publicly owned suburban water utilities can be established and operated effectively. For example, this can be done in Ohio through the organization of county sanitary districts under the authority of the county commissioners. Suburban water districts likewise can be set up in Indiana under the provisions of a "conservation district" enabling act. Before deciding upon the development of a publicly owned suburban water utility, however, careful consideration should be given to the possible organizational difficulties. Concerning such proposals, Tableman (*13*) states:

> Thus, city officials should be exceedingly loath to encourage the formation

of a special district. Whereas the special district is an easy immediate solution to the fringe problem, in the long run it is likely to create more problems than it solves. Before yielding to the special district, city officials should carefully consider provision of services by the city as a preferable solution to the fringe problem.

If circumstances are such that there is no choice but the creation of a special district, then city officials should try to see that the following safeguards are adopted: [1] that the special district covers as large an area as possible, preferably including the city as well as the fringe area; [2] that the directors of the special district are existing officials ex officio or are appointed by the legislative body or executive head of existing governmental units. In this way certain problems may be lessened in that an areawide district can better cope with its assignment and a special district whose directors are tied in with existing units is more likely to achieve coordination.

Metropolitan Water Utilities

In special circumstances, it may be that the most feasible method of providing suburban water service will be for the suburban areas or municipalities to go into partnership, as it were, and establish a publicly owned metropolitan water district. The formation and operation of such districts, incidentally, tends definitely to discourage annexation to the parent city.

An example of a metropolitan water district that provides complete water service, both supply and distribution, for its service area is the East Bay Municipal Utility Dist., which serves Oakland, Palo Alto, and a number of other municipalities and suburban areas across the bay from San Francisco, Calif. In contrast is the Metropolitan Water Dist. of Southern California, which develops the supply but sells water wholesale to its constituent utilities for retail distribution. This district, a governmental subdivision of the state of California, was established and is operated in accordance with the provisions of the Metropolitan Water Dist. Act adopted by the California legislature in 1927 and since amended from time to time. Organized in December 1928, the district included, as of June 1, 1952, a total of 45 incorporated cities and large unincorporated areas. Among the larger of these cities are Los Angeles, Pasadena, and San Diego. The district has a total area of 1,521 sq miles, a population of nearly 4,000,000, and a total assessed property valuation of $5,000,000,000.

Suburban Water Rates—Metered Service

No matter whether the parent utility elects to extend its system into outlying areas or to sell its water through master meters to secondary utilities, the question of what rates the producing utility should charge for the suburban water service will very soon arise. Should the suburban customers, whether individuals or a utility, be charged the same rates as the urban customers, or should the suburban rates be higher? The answer to the rate question must be developed carefully lest the extension of suburban service be detrimental to the best interests of the taxpayers and stockholders.

It definitely costs more to furnish water in outlying districts than in the basic service area within a municipality (*14, 15*). In the first place, longer trunk mains must be built and more friction must be overcome in the dis-

tribution system of the primary area before the water can reach the suburban district. Further, as the lots in suburban areas normally have greater frontage and probably will not be so fully developed as in the basic service area, less business can be expected per mile of main in the suburban districts.

In many suburban areas, the mains will have to be laid in streets which have not been permanently graded, with the result that it may be necessary later to relay or lower the mains. For that reason, it would be desirable, if expedient, to provide that water mains be installed only in streets permanently graded in advance of construction.

To do otherwise may subject the utility to the expense of lowering the mains, unless very careful study is given to each suburban main extension to determine that it is being laid at a grade consistent with future street development. Other factors also add to the cost of doing business in suburban areas.

Establishing suburban water rates of a higher order than those prevailing within the city does not discriminate against suburban customers, for, as has been shown, it costs more to serve the outlying areas. Therefore, it appears reasonable and proper that the suburban customer should pay a higher rate than the customer within the basic utility service area.

At Kansas City, Mo., the suburban water rates are materially higher than those charged to city customers. Differential suburban rates also prevail at Chicago, Omaha, Denver, Seattle, Indianapolis, Milwaukee, and many other large cities. At Cincinnati, the suburban rates are generally 100 per cent greater than those charged to city customers. According to Dale L. Maffitt (*16*), "In a questionnaire answered by 77 of the larger cities in this country, it was shown that, in approximately 75 per cent of the cities, higher rates are charged to consumers living outside the city limits than are paid by those living in the city, and those rates sometimes run as high as 100 per cent greater."

In the case of Milwaukee, Wis., versus West Allis (one of its suburbs), the Milwaukee Water Dept. attempted to collect higher charges for water service from the defendant than were paid by city residents. The court held that "there may be a different charge between the residents of the plaintiff city and outsiders as to water furnished. No discriminating results from the rates charged and received by plaintiff from resident consumers . . . and those [rates] herein found to be the reasonable value of the service rendered by plaintiff to defendant. . . ." A comprehensive discussion of the factors leading to this conclusion by the court will be found in a paper by J. P. Schwada and E. F. Tanghe (*14*).

Suburban differential rates at Kansas City, Mo., are based largely upon "distance and demand factors," as explained by Melvin P. Hatcher, Director, Kansas City, Mo., Water Dept., in an excellent paper (*15*) published in 1950. W. Victor Weir (*8*) has given a concise statement of the principles involved in the establishment of differential rates, together with an example based upon these principles. The following excerpt clearly illustrates his philosophy on this subject:

That water rates outside a city should be higher than water rates inside a city is generally accepted. As the adequacy of water rates has an intimate relationship to extension policy, a few of the

factors concerning suburban rates should be mentioned:

1. City rate schedules are based on cost of serving average customers, some located near the center of the city and some near the city limits; the suburban schedules apply to customers who are all outside the city limits, thus requiring a maximum of facilities.

2. City rate schedules of municipal utilities usually contain no charges for facilities which have been paid for by tax assessment or by the application of surplus accumulation; new suburban customers have made no such payments and their rates should be high enough to make up the difference.

3. The interest rates to be applied against the investment provided by the city water users or taxpayers should not be the interest rate at which the city can borrow money, but should be the value of money to the individuals who paid for the facilities through water rates or taxes, probably an average of 6 per cent. Depreciation should also be included at 1.5 or 2 per cent. As the operation is a municipal one, no property or income taxes are involved.

An analysis might show, for example, that the debt-free value of a municipal water works system is $150 per minimum customer. If the water rates were carefully designed, and showed that the minimum charge inside the city should be $12.00 per year, then the minimum charge outside the city should be at least $11.25 per year higher (7.5 per cent of $150 for interest and depreciation). The annual minimum bill should properly be even higher than $23.25 because the distance factor to the outside customer has not been added.

As previously mentioned, a superior court of Pennsylvania has held that a municipal utility which does not attempt to operate at a profit within the city nevertheless can properly add a differential to its suburban rates to yield a profit over and above the added cost of operation (*8*). The court stated: " . . . it should be noted that a municipal water company may serve residents within the city at cost, but is entitled to a profit on service in territory outside its boundaries. (*Ambridge* v. *Public Utility Commission* (1939) 137 Pa. Super. Ct. 50, PUR NS 50, 8 A2d 429.)

In establishing a differential suburban rate, an increment should be applied to the basic rate to cover added operating costs involved in supplying service to the outlying area. Municipally owned utilities not operating at a profit or charging off depreciation on property within the city should include a further increment to provide a profit or obtain a share of the depreciation cost from suburban customers.

Those developing or reviewing existing suburban rates are warned that, although differential rates are considered proper and equitable, they should be based upon definite extra-cost factors. This principle was stated clearly by the Public Service Commission of Montana (*9*) in reviewing a petition of Helena to increase minimum charges outside the city: "This Commission has held that when the city elects to furnish water to consumers outside of the city it stands on the same footing as a private utility, and that no different rates may be approved for such out of city service unless they are justified on an actual cost basis."

It also is necessary that, once established, differential rates be applied consistently. This principle was upheld in the Texas supreme court, by a five-to-four vote, in a 1952 decision on suburban rates being charged at Texarkana:

We think the effect of the statute is that when a city decides to exercise this power to provide its utility service to customers outside the city limits it may then fix such service charges as it decides the situation requires; if it requires a higher charge than is fixed against residents of the city for the same service, the city may exact the higher rate. But whatever it fixes, a rate status between the city and its outside customers is thereby established and the city cannot thereafter arbitrarily change the rate so as to discriminate, or further discriminate, between them and customers residing in the city. This conclusion is certainly in line with well-established principles of public utility law.

For these reasons we hold that the statute did not change the common law rule prohibiting unreasonable discrimination. The ordinance is therefore void unless the Petitioner can show, on another trial of the cause, that there is some reasonable basis for the difference in rates which it establishes. In order that the Petitioner may have an opportunity to make such a showing the judgment of the Court of Civil Appeals reversing and remanding the cause is affirmed.

For those desiring to study further or to develop differential suburban rates, examples of such rate schedules have been included in an appendix to this report.

Suburban Water Rates—Public Fire Protection

The discussion up to this point has applied to metered water sales only. In determining proper suburban rates, a complication often arises when charges for suburban public fire protection water service or hydrant rental are considered. Charges for such service within a municipality normally are paid by it from funds derived from the collection of ad valorem taxes. This is equitable because the extension of municipal fire protection is a benefit to the entire community and not to the water consumers only. In suburban areas, however, it becomes quite difficult for the water utility to collect such charges, for, except in sanitary or water districts, there usually exists no public agency with the necessary taxing powers.

Several states authorize the establishment and operation of suburban water utility districts. These utilities furnish water service in suburban and rural areas, collecting for public fire protection in the same manner as publicly owned water utilities within cities and towns. Such suburban water utility districts are established by proceedings initiated by, or through, officials corresponding to county commissioners in most states. Although these districts have been organized primarily for the extension of complete water service to suburban customers, it should be possible to adapt such a scheme to the establishment of special fire protection taxing districts in the counties surrounding municipalities that furnish suburban water service, provided, of course, that the legislature can be prevailed upon to pass the necessary enabling legislation. A rather complicated legal procedure is required for the creation of such special taxing districts, however, and the scheme would hardly be adaptable for small subdivisions or main extensions serving small areas.

In California, county boards of supervisors are authorized to establish county "fire districts" and to collect special fire district taxes to pay for hydrant rental. Under this system, the parent utility can extend its distribution sys-

tem into suburban areas and collect hydrant rental charges from the county "fire districts."

In at least one state, Indiana, it is possible to develop a plan that indirectly enables a water utility to collect suburban fire protection charges. Township fire departments can be organized with authority to collect taxes for their operation. From these funds, hydrant rental or public fire protection water service charges can be paid. This system would be more equitable for those not having fire hydrants available than levying of taxes to pay for the water service only would be, because everyone, even including those with no protection from fire hydrants, would enjoy a measure of fire protection from chemicals and water carried by the fire trucks.

Surcharges

Probably the most readily applicable, but not necessarily the most equitable, method of paying for public fire protection water service in suburban areas would be for the charges to be borne by the customers, either in the differential rates or through payment of fire protection surcharges. In some localities where this system has been followed—Seattle, for example—a uniform surcharge for fire protection water service has been levied upon all suburban customers. In other instances, the amount of the surcharge varies with the service or meter size. At Indianapolis, suburban customers pay the same basic metered service rate as do city customers, plus a suburban water service surcharge ranging from 75 cents per month for a $\frac{5}{8}$-in. meter to $30 for a 6-in. meter. Admittedly, the value of combined metered and fire protection water service extended to suburban customers is not necessarily in direct proportion to the meter size, but it does reflect the benefit to some degree. There is also extra expense involved in providing metered water service to larger customers. A surcharge established as a percentage of the water bill would probably result in a charge more in proportion to the benefits derived from the fire protection water service.

In general, it would appear equitable, as between water customers of a given class, to establish a surcharge as a means of paying for public fire protection water service in suburban areas—equitable, that is, if it can be considered just to charge only the water customers for such service, which is available not only to them but also to their neighbors not using city water.

Be that as it may, payment for public fire protection water service in suburban areas should be provided from taxes, differential suburban rates, or through collection of surcharges. Examples of rate schedules providing for payment of suburban surcharges will be found in the Appendix.

Suburban Main Extension Policies

Having determined that it would be desirable to extend water service into a suburban area and having decided upon the rates to be charged, the utility is still faced with the equally important problem of determining how the cost of constructing main extensions into the area can best be defrayed. Some state commissions that regulate public utilities have established or recommended rules governing the extension of mains by private utilities. Other

state utility commissions have developed no detailed policies but review problems arising in connection with such main extensions upon their individual merits. In a number of states, the commissions have no jurisdiction over such problems. The operations of municipally owned utilities within the city are not normally under commission jurisdiction, but, in some states, the commission may take an interest in suburban operations, as, in that field, the municipalities may be said to assume the role of a privately owned utility. It will often be found, however, that, even though the commission has no jurisdiction, the municipal utilities adopt the same main extension policies as the privately owned systems. In view of these variable circumstances, this committee cannot expect to present generally acceptable, detailed methods of financing suburban main extensions. It is possible, nevertheless, to outline the broad principles upon which acceptable suburban extension policies can be based.

Principles

In 1949 this committee presented a progress report (*1*) in which fundamental water main extension policies were discussed. As these principles are equally applicable to suburban extensions, it appears worth while at this point to restate them. Main extension policies should: [1] be nondiscriminatory; [2] be based upon business principles; [3] assure that main extensions will be self-supporting; [4] provide for customer participation in the financing of extensions where service is needed within the established service area if the anticipated revenue is insufficient to warrant the utility's making the extension unassisted; [5] be implemented by the adoption and promulgation of comprehensive rules, which should be reviewed periodically.

Utility Rules

In accordance with these principles, definite, nondiscriminatory rules should be developed for administering these policies. Before such rules are drawn up, the 1949 progress report of this committee should be reviewed.

In developing suburban main extension rules, it is of the utmost importance to publicly owned utilities that the municipal authorities completely understand and approve the financial arrangements by which it is proposed to finance extensions beyond the corporate boundaries.

Precautions should be taken, in implementing suburban main extension policies, to devise financing rules that will obviate the necessity of raising the basic rates in order to defray the cost of providing plant additions required by such extensions. The extension of service into suburban areas will use up an increment of plant capacity that otherwise would have been available for the customers within the city. As a result, sooner or later it will be necessary to expand these facilities, except in those unusual instances where the extent of suburban expansion is within the limits of existing excess plant capacity. If the net revenue accruing from the extensions is not sufficient to pay for plant expansion, it becomes necessary to raise the rates for all customers, a procedure that is normally unfair to inside-city customers. To avoid this situation, the financing rules adopted should be designed to assure that the ratio of the revenue from the extension to the investment assumed by the utility will be sufficient

to make the extension self-supporting. To meet this requirement, the revenue from the extension must not only pay the operating costs resulting from its addition to the system, but must also defray the fixed charges on the increment of utility plant devoted to its service.

In special circumstances it may be deemed advisable by the agency operating the primary utility to make extensions on a more liberal basis, but, when that is done, it should be realized that the suburban areas are, in effect, being subsidized at the expense of the customers within the basic area. It may, for example, be desirable to promote suburban development for the purpose of relieving urban overcrowding or for remedying a health hazard that might affect the entire community.

In developing the rules to be adopted for implementing the main extension policies, certain fundamental principles should be observed. These are outlined below.

Ownership of Extension

The title of ownership of an extension should always be vested in the utility, regardless of the advances in aid of construction given by promoters or other customers. The utility must undertake the maintenance and the ultimate replacement of the pipe and must have full control over it, including the right to connect additional customers without the consent of the promoter or other parties helping to pay for its construction.

Further Extensions

The utility should definitely reserve the right to make further main extensions beyond or laterally from the extension being paid for. Further extensions should not be considered additional connections to the extension and should not entitle the original promoter to a refund.

Pipe Sizes

The utility should always determine the size and type of pipe for the extension. If the utility wishes to install larger pipe than that reasonably required to serve the territory to be traversed by the extension, the excess cost, under prevailing practice, would be borne by the utility. The relation between the cost of the proposed extension and the revenue estimated to accrue from it should not, however, be allowed to influence the utility in determining the size of the pipe actually to be installed. The pipe size normally selected should be sufficient to yield proper fire flows. Extensions smaller than 6 in. in diameter should be considered as affording domestic service only and should be installed only in cross streets where they will not be called upon to serve fire hydrants, fire protection being afforded by hydrants in adjoining streets served by an adequate grid system.

It has recently been suggested by a committee of the Indiana Section, AWWA, under the chairmanship of A. O. Norris (*8*), that the utility should not make the customer responsible for a size of pipe large enough to provide fire protection for the areas immediately adjacent to, or fronting upon, the street in which the main is being laid. The basis should rather be the weighted average size of main in the system, exclusive of feeder and trunk mains. This method would appear to be equitable, as it gives recognition to the fact that all mains in a grid system cannot be of the minimum size

necessary to provide proper fire flows in areas remote from the feeder or trunk mains. Such a provision would afford some relief to the utility, and would likewise provide a means of equalizing charges for customers served from, say, 2-in. mains in cross streets who are enjoying fire protection water service from larger mains in adjoining streets.

Utility Investment

The rules should specify the amount of investment to be made by the utility in suburban extensions. It the utility commission having jurisdiction has promulgated specific regulations on the subject, the utility should, of course, follow these requirements in drafting its own rules. It should, however, review the effect of long-continued application of such regulations upon its financial structure and, if it is definitely unfavorable, should petition for relief.

Different policies on subdivisions prevail in different localities. In some places, it has been the practice to require developers of subdivisions to pay the entire cost of installing water distribution mains, in recognition of the fact that the promoter will recover the cost of the installation from the sale of lots. In other utilities, provision is made for future refunds to promoters when business develops within the subdivision. It is not within the province of this report to state which method is proper, for circumstances vary. Many believe, however, that the subdivider should not be subjected to rules or plans that differ from those applied to other customers desiring water service extensions. Of course, if the subdivider merely sells lots and it is left to chance or to the demand for residential building in the area to develop business for the utility, the subdivider should advance the entire cost of the installation. Usually he should receive the same refund when business develops as do others who help finance water main extensions. On the other hand, when the subdivider builds houses as part of his project, the subdivision may be completely developed as soon as the main installation is made. Under such circumstances, it would appear equitable for the subdivider to be given credit for the business received by the utility and for the utility to pay a commensurate part of the extension cost, if the same privilege is given to individual applicants for extensions.

The committee has agreed (*1*) that the utility investment in a water main extension should properly be based on the amount of revenue to be derived from the extension rather than on the average width of the lots, the average number of feet of main per customer on the existing distribution system, or similar criteria expressed as the number of feet of "free" extension to be allowed per customer. To base the "free" extension upon a stated number of feet of main per customer is to place the utility in an embarrassing position in times of rising prices, because the revenue dollar remains stable in relation to the number of gallons of water it will purchase while the value of the construction dollar used to pay for main extensions diminishes. This forces the utility to invest more and more of its revenue dollars to pay for the stated length of main that will be installed free of charge. Should the water rates be adjusted each time an extension is made, this inequity would not occur, but this is not practicable. It was the consensus of the committee, in its 1949 progress report (*1*), that the amount

of the "free" extension should be expressed in dollars rather than in feet of main.

The same situation will prevail in the case of suburban main extensions. Therefore, the utility investment in a suburban extension should be expressed in terms of the number of dollars that the utility will invest for each dollar of revenue per anticipated customer on the extension, and not in terms of a stated number of feet of main per customer.

Actually, the crux of the suburban water main extension problem, as it relates to the length of the "free" extension or the investment the utility will make in it, lies in the determination of the amount, in dollars, that the utility can afford to contribute toward the cost of the extension. A number of methods of computing this investment are in use throughout the country. Most of them are based upon the philosophy, aptly stated in 1941 by F. R. Berry (*17*), that, in establishing the amount of money the utility can afford to invest in a main extension, recognition must be given to the fact that the extension costs are only a part of the expense being accepted by the utility when an extension is made.

Berry clearly outlined a method of computing the proper investment to be made in extensions by developing a relationship between anticipated revenue, operating ratio (the percentage of the gross operating earnings expended for operation, maintenance, and taxes), ratio of pipeline investment to total investment, and proper rate of return.

In 1949 A. O. Norris (*18*) also described a method of basing the utility investment in main extensions on the same factors. Later, in 1952, Norris (*8*) reduced these relationships to an algebraic expression that can easily be solved. As this formula offers a ready means of computing the proper utility investment in a main extension, it is presented here, along with the example used by the author.

Let X equal the amount in dollars that properly can be spent on a main extension; A equal the anticipated gross annual revenue from the extension; B equal the operating ratio; C equal the percentage of total plant that is invested in pipelines; and R equal the proper rate of return (applicable to privately owned utilities or to municipally owned utilities operating in suburban areas), or the percentage of total investment needed annually to cover the cost of borrowed money (applicable to publicly owned utilities in the basic service area). The formula is:

$$X = \frac{(A - AB)\ C}{R}$$

Assuming A is \$30 a year, B is 60 per cent, C is 40 per cent, and R is 6 per cent:

$$X = \frac{(\$30 - \$30 \times 0.60)\ (0.40)}{0.06} = \$80$$

Therefore, for a rate of return of 6 per cent, the utility can invest \$80 in a main extension to serve a customer who will yield \$30 in annual revenue.

In its 1949 report, this committee presented a different method of determining the investment to be made in a main extension but one that will yield the same result as the above formula. The committee's method employs basic data on revenue and expense instead of using the operating ratio as such.

With either method, the ratio of the computed amount of the "free" extension investment, X, to the anticipated revenue, A, is a "multiplying factor" that can be applied to the anticipated

revenue from other extensions to yield the proper free investment. In the Norris example, divide \$80 (computed investment in the "free" extension) by \$30 (anticipated revenue) and develop 2.5 (approximately) as the multiplying factor to be used in determining proper extension investments when different amounts of revenue are anticipated.* Thus, should it be estimated that there will be ten customers on a proposed extension and that their average annual water bill will be \$30 each, the amount that the utility should invest in the extension would be $10 \times \$30 \times 2.5 =$ \$750.

The committee cautions those developing a plan based upon revenue accrued from suburban extensions that, when differential rates are charged for suburban water service, the increment, being based upon added cost factors to the utility, should not be included in the anticipated revenue for the purpose of computing the investment in "free" extensions. To include it would give the prospective suburban customer an unfair advantage over the customer in the basic area, in addition to penalizing the utility (*8*).

Other methods of determining the "free" extension are used in various states. Some of these will be outlined later in connection with a discussion of public utility commission viewpoints.

Customer Advances and Contributions

1. *Deposits.* In developing suburban main extension rules, it should be provided that, when the cost of the required extension exceeds the amount which the utility is justified in investing in a "free" extension, the customers shall deposit the difference with the utility as an "advance in aid of construction." It may be, as at Sacramento, Calif., that the water rates are so low that the revenue will be insufficient to warrant any "free" extension whatever.

2. *Frontage fees or connection charges.* When immediate customers post a deposit to make up the difference between the total cost of an extension and the investment by the utility in a "free" extension, subsequent customers usually become "free riders." This is not equitable and gives rise to dissatisfaction on the part of the original deposit payers. As a means of correcting such situations, some utilities collect frontage fees or connection charges from subsequent customers. These charges are then turned over to the original deposit payers as a means of assisting in the refund of their deposits. When all of the deposits have been refunded, the frontage fees or connection charges can be allowed to accumulate until the stated refund period has elapsed and then refunded proportionately to all frontage fee payers. After that, no fees are collected. Frontage fees usually are computed by dividing the total cost of the extension by the total frontage, thus arriving at a unit price per foot of frontage. The fees for individual customers can then be computed by multiplying their frontage by this unit price. Connection charges can be similarly established and refunded. The amount of the charge can be computed by estimating the degree to which the extension area will be developed during the refund period and dividing the total cost of the extension by the number of customers anticipated. The Louisville, Ky., Water Co. has developed a connection charge system

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* The multiplying factor can also be found directly from the formula by solving for $\frac{X}{A}$.

that it successfully applies to suburban main extensions.

3. *Guaranteed revenue*. Some utilities will accept a guarantee of the minimum revenue required to support a "free" extension. In applying this scheme, at the end of each year the aggregate revenue is determined and the guarantors make up the difference, if any, between the actual revenue and the guaranteed amount. This system obviously is practicable only if the guarantors are financially responsible.

4. *Special assessments*. When the utility is municipally owned, special assessments, usually based on frontage served, are often levied to pay for main extensions. This method, however, is not available to municipally owned utilities in extending their service into suburban areas. It could be adopted, however, in suburban areas served by utilities owned by special taxing or metropolitan districts. Such assessments are not truly advances in aid of construction, as no part of them is refundable. Rather they become contributions in aid of construction.

5. *Surcharges on water bills*. A plan sometimes used to help finance water main extensions is based upon the collection of surcharges added to each bill. Such surcharges are established as a percentage of the bill for metered service. This plan has the advantage to the customer of permitting him to pay his advance in installments rather than in a lump sum. When such a system is followed, it usually is provided that, if the extension exceeds a certain length over the "free" extension limit, it will be necessary for the customers involved to make a lump-sum advance as well as to pay the surcharge on the water bills. Public service commissions in at least two states, New York and West Virginia, base their rules for making extensions upon such a plan.

Refund of Advances

In most plans, provision is made in the rules for the advances in aid of construction to be refunded, at least in part, by stating that during the development period—often assumed to be 10 years—the utility will refund to the payers each year a sum based upon the revenue derived from the new customers connecting to the extension during the year. The amount of the refund is computed in the same manner as the value of the "free" extension. The rule should provide that, if the entire advance is refunded before the expiration of the stated development period, no further refunds will be made. In addition to the refunds made by the utility in recognition of added revenue, frontage fees or connection charges collected from subsequent customers may be used to refund part of the outstanding advance. This matter has previously been discussed.

Large water users who have assisted in financing main extension sometimes receive rebates of a stated portion of their annual water bill. The percentage rebated usually is related to the length of the development period during which refunds will be made. In following such a plan, care must be exercised lest the customer be encouraged to waste water and thus unfairly increase the amount of his refund.

Under plans providing for assessments and guaranteed revenue, no refunds are made.

Any liability for refund of the balance of an advance in aid of construction should cease at the end of the development period. This provision should be clearly stated in the rules to

prevent disputes over ownership or further obligation of the utility. Any unrefunded balance of an advance automatically becomes a contribution in aid of construction at the end of the development period.

In computing refunds on a revenue basis, the differential charges levied upon suburban customers to compensate the utility for the added cost of serving them should not be considered revenue.

Public Service Commission Rules and Policies

Public service commission jurisdiction over water utilities varies widely from state to state. There are states where the commissions that exercise jurisdiction have not established policies on water main extensions. Other commissions act in advisory capacities only, while some judge individual main extension problems upon their merits and issue orders based on findings in each instance. In at least five states, the utility commissions have adopted definite regulations on main extensions. Before establishing rules on suburban extensions, the utility management should determine the attitude of the commission. This applies even to municipally owned utilities, which in most states are not under commission jurisdiction. The main extension policies of privately owned utilities often set a pattern on which municipal rules can well be based. Furthermore, commissions may have jurisdiction over the suburban operations of municipally owned utilities. The Kentucky Court of Appeals held (*10*) that the public service commission "has jurisdiction over rates charged and services rendered by a city-owned water company as regards water furnished to consumers residing outside the city limits. Cities are free of regulation by the Commission only within their corporate limits and when, in the instant case, the city supplied water outside its corporate limits, its exemption from regulation as to rates and services by the Commission ceased. Therefore, the city was properly enjoined from fixing rates applicable to water users beyond the city boundary."

A contrary opinion has recently been expressed by the attorney general of Nevada (*19*), but it is believed possible that all of the issues in the case were not fully developed. Be that as it may, it behooves the management of municipally owned utilities that either are extending or plan to extend service into suburban areas to reckon with the possibility that the public service commission in their state may have jurisdiction over their suburban activities.

In 1952 Fred Witherspoon, Engr., Indiana Public Service Commission, conducted a survey of public service commission policies on main extensions in nineteen states and kindly made his files on the subject available to this committee. Table 1 has been prepared to show typical requirements and policies of representative commissions. The lack of uniformity in the degree of jurisdiction exercised and in the commission requirements or provisions suggested for adoption by the utilities is astounding. Of the nineteen commissions included in the study, only the nine shown in the table had specific requirements or had developed definite bases for the implementation of main extension policies. Four others—Georgia, Nebraska, Minnesota, and Iowa—have no jurisdiction over water utilities.

TABLE 1—*Comparison of Public Service Commission Requirements*

State	Basis of Supervision	Utility Investment	Applicant's Investment	Refund per Additional Customer	Limit of Refund Period	Remarks
Indiana	commission rules	6 times annual revenue*	balance	6 times annual revenue*	8 yr	revision to 4 times revenue requested by Indiana Section, AWWA
Kentucky	commission rules	50 ft	balance	none		applicant must contract to use water 1 yr
West Virginia	commission rules	60 ft	surcharge—11% of balance (pvt. util.) or 9% (munic. util.)	60 ft	10 yr	subdivider pays total cost subject to refund equal to cost of 60 ft of pipe per customer for 10 yr
New York	commission rules	75 ft plus 20 ft per hydrant	surcharge—9% of balance*	none		when revenue equals 25% of extension cost, no surcharge
New Jersey (Dept. of Utils.)	commission rules	3½ times annual revenue	balance deposited and held until revenue equals that required for free extension*	only if revenue meets requirements in 10 yr	10 yr	alternate: applicants may guarantee monthly revenue equal to 1/42 of extension cost up to 50% of cost
Massachusetts (Dept. of Public Utils.)	individual merits	decisions of commission have led utils. usually to make extensions if applicants guarantee revenue equal to 15% of extension cost for 5 yr				after hearing, dept. may require extension; utils. may file rules
Illinois (Commerce Com.)	reviews and approves util. rules	2½–4 times annual revenue*	balance*	amount equal to util. investment in free extension*	10 yr	typical terms
Missouri	utils. file rules	$50 or 4 times annual revenue*	balance*	as above*	10 yr	typical terms
Wisconsin	suggests typical rules to be adopted by utils.	50 ft if main supplies hydrants; 100 ft if general service only	balance	as above*		new customers pay connection charge equal to outstanding avg contribution, which is refunded pro rata to all customers, including new ones, on extension

* See "Remarks."

Certainly there is a need for the work now being done by NARUC in developing uniform rules. In view of the diversified opinions on proper water main extension rules and in consideration of the project being undertaken by NARUC, it can be seen that this committee is not now in a position to present a specific set of main extension rules to the water works industry.

Summary

The Main Extension Policy Committee, in studying the suburban main extension problem, found it necessary to broaden the scope of its investigation to include legal and civic, as well as financial and administrative, aspects. Further, the matter of suburban water rates was so closely related to main extension financing that a review of policies on such rates likewise had to be undertaken.

Because of the great diversity of practice and circumstance, it was concluded that, *at this time,* it would not be feasible to develop specific recommendations on administrative practices. Certain general conclusions can be drawn, however, remembering that exceptions to them can readily be found.

Under normal circumstances, if the system is adequate, it usually can be concluded that, in the absence of contrary charter provisions, public service commission rulings, or impeding financial obligations, it will be legal to extend water service into suburban districts. Likewise, it will be desirable to extend such service, provided the suburban business is developed upon a sound financial basis and proper safeguards are established to protect the city against uncontrollable fringe growth. The indiscriminate extension of water service into suburban areas enables these districts more readily to defy the efforts of the city to annex them.

Should it not be feasible or desirable to extend service into suburban areas from the water works serving the parent city, suburban water districts can be established if the creation of such districts has been authorized by the legislature. Suburban water service also can be provided by privately owned suburban water works. Under special circumstances, metropolitan water utilities can be developed and operated successfully. Such utilities, in effect, constitute a partnership between the parent city and the outlying areas. It may be anticipated that the establishment of suburban water districts, suburban water companies, and metropolitan utilities will make more difficult the annexation of the suburban areas to the parent city.

Rates for suburban water service should produce sufficient revenue to pay for the added cost of service and also yield a profit. Court decisions indicate that a municipally owned water works can establish suburban rates that will yield a profit even though the utility might not derive a profit from its operations within the city. As municipal utility operations outside the city are in the same category as those of privately owned utilities, suburban rates may be subject to the jurisdiction of the public service commission, even though it may have no control over the rates charged within the city.

It is somewhat difficult for the central utility to collect charges for public fire protection water service from suburban areas. It can be done, however, through the creation of "fire districts," as in California, or through the applica-

tion of surcharges to the bills for metered service. Other, less usual, methods also are available.

Suburban main extension policies should be based upon the same principles as those applicable to service within the city. The suburban policies should:

1. Be nondiscriminatory.
2. Be based upon business principles.
3. Assure that the main extensions will be self-supporting.
4. Provide for customer participation in the financing of extensions if the anticipated revenue is insufficient to warrant the utility's financing the extension unassisted.

Rules should be adopted to guide the application of these policies to the extension of mains into suburban districts. These rules should provide:

1. That the ownership of the suburban main extensions be vested in the utility, even though others may assist in financing their construction.
2. That the utility have the right to make further extensions without incurring additional obligation to the original extension promoter.
3. That the utility determine the size of the pipe to be installed and that it be of sufficient size to yield proper fire flows and permit further extension, even though the promoter is charged only for a pipe of sufficient size to afford proper service in the immediate area traversed by the extension.
4. That the utility investment in a suburban extension should be based upon the amount of revenue to be derived from it, the relation of the operating ratio to the value of the existing distribution mains being a yardstick for use in determining the proper utility investment in the extension.

Public service commission rules or policies governing the suburban extension of water mains vary widely between states. NARUC now is developing uniform rules, and it is hoped that, when completed, they will promote the establishment of uniform policies and procedures for extending water service into suburban areas.

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APPENDIX

Differential Suburban Rates

Suburban rate schedules illustrating the principles discussed in the text of the report are presented in this Appendix, not because they will be applicable to other utilities but rather because they may show how certain

Los Angeles Rates

Monthly Minimum Charge

Meter Size *in.*	Inside City $	Outside City $
1 or less	1.10	1.69
1½	1.65	2.54
2	2.20	3.38
3	3.30	5.07
4	4.40	6.76
6	6.60	10.14
8	8.80	13.52
10	11.00	16.90
12	13.20	20.28

Metered Rates

Quantity *cu ft*	Inside City *¢/100 cu ft*	Outside City *¢/100 cu ft*
First 3,300	14.8	
Next 30,000	13.7	
***		
Over 10,000,000	4.0	
First 500		30.0
Over 500		20.0

Metropolitan Utilities Dist. (Omaha, Neb.) Rates

Quantity *cu ft*	Inside City *¢/100 cu ft*	Outside City *¢/100 cu ft*
First 500	15	
Next 13,500	12.5	
Next 986,000	8	
Next 500,000	7.5	
Next 1,500,000	6.33	
First 500		22.5
Next 1,500		18.75
Next 12,000		15
Next 986,000		8
Next 1,000,000		7.5
Over 2,000,000		7
Min. monthly bill	$0.60	$1.00

Indianapolis, Ind., Water Co. Suburban Surcharge

Meter Size *in.*	Monthly Surcharge $
⅝	0.75
¾	1.80
1	2.70
1½	4.20
2	6.60
3	12.00
4	18.00
6	30.00

utilities have established differential suburban rates and how others are collecting indirectly for suburban fire protection water service through the application of surcharges to their basic rate schedules. These rate schedules are not offered as models or suggested as being suitable for adoption by others. Recommendations on rate schedules are in the province of the AWWA committee on rates and are not within the purview of the present committee.

Revision of Tank Painting Standard

On June 2, 1953, the AWWA Board of Directors approved revisions to the Tentative Recommended Practice for Painting and Repainting Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage—AWWA D102. The changes affect the following sections: Sec. 3.2.6, Sec. 4.2.1, many parts of Sec. 5 (particularly 5.4), Sec. 6, and parts of Sec. 7.

In general, the more important changes were those made to restrict the use of cold-applied coal-tar paint (CA–50) to parts of tanks above high-water level, and to permit the use of cold-applied tasteless and odorless tar-base paint.

As in the past, reprints of the new version (D102–53T) will be made available in conjunction with either the tank specifications, D100, or the tank inspection and repair standard, D101. The D100-D102 combination is priced at 70¢; D101-D102 at 50¢.

Application of the Microstrainer to Water Treatment in Great Britain

By Richard Hazen

A paper presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by Richard Hazen, Partner, Hazen and Sawyer, New York.

THIS paper presents a brief report on "microstraining" or fine-wire straining of raw water as practiced in Great Britain. The author has been interested in this development for some time and has taken the opportunity to visit some of the installations. The data presented were obtained from published papers and reports *(1–4)* and from correspondence with British water works officials and manufacturers.

It should be stated at the outset that, up to the present, the microstrainer has found its greatest application in the pretreatment of water ahead of slow sand filters. The slow sand filter has been the work horse of British water purification for more than 100 years, starting with Thom's first filters at Greenock, Scotland, in 1827 and Simpson's filters at London in 1829. In spite of the trend away from slow sand filters toward coagulation and rapid sand filtration, slow sand filters render excellent service in many places here and abroad. The latest plant of the London, England, Metropolitan Water Board, under construction at Ashford Common, will have 32 beds of $\frac{3}{4}$ acre each and a total capacity of 108 mgd.* There is a tremendous investment in slow sand filters in Great Britain, and much attention has been devoted to means of increasing their capacity and effectiveness.

One of the obstacles to slow sand filtration in Great Britain is the periodic dense growth of algae in the raw water. The algae clog the filters rapidly and the output is seriously limited at certain times of the year. In the London water supply, relatively polluted water is taken from the Thames and Lee rivers and is stored in open, shallow impounding reservoirs. The filters are also uncovered. The open storage of water relatively free from turbidity but rich in organic matter is ideal for the development of algae.

For many years the Metropolitan Water Board and other water departments have countered the algae growth by "double filtration." A scrubber, or prefilter, similar in most respects to the American rapid sand filter with relatively coarse sand, is built ahead of the slow sand filter. No chemical coagulation is provided, but the prefilters remove most of the algae and turbidity. The worth of the prefilters is indicated by the relative loading of the several filter plants of the Metropolitan Water Board during 1949, summarized in Table 1. It will be noted that the filter rates in the plants with prefilters are al-

* Quantities given in U.S. gallons throughout.

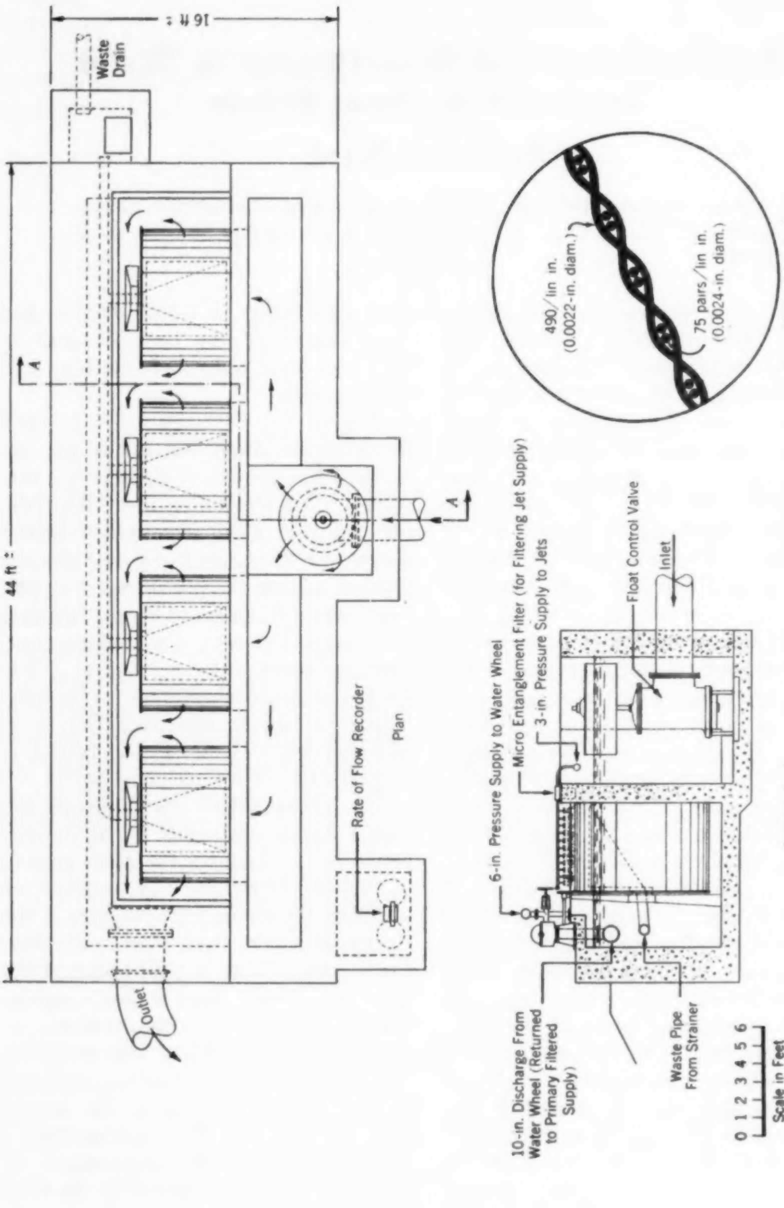

Fig. 1. Simplified Diagram of Kempton Park Microstrainer Installation

most 2.5 times the rates through the plants without prefilters.

Microstrainer Features

In many plants, the microstrainer is now installed in place of the usual prefilter. The microstrainer, a rotating drum filter with a stainless steel wire fabric (Fig. 1), is manufactured by a British firm.* Since 1947, when the first unit went into operation, microstraining plants with a total capacity of more than 310 mgd have been installed or placed under construction. The general features of these installations are illustrated in Fig. 2, which shows the layout of four experimental strainers at the Kempton Park plant of the Metropolitan Water Board. Figure 3 is a photograph showing three of the units.

The significant characteristic of the microstrainer is the extremely fine stainless steel fabric (Fig. 4). The fabric is made up of 75 pairs of warp wires (0.0024-in. diameter) per inch and 490 weft wires (0.0022-in. diameter) per inch. There are approximately 73,500 openings per square inch, with the inner and controlling apertures having a nominal size of 35μ, or 0.035 mm (Fig. 5). The strainer is successful not only because the fabric provides extremely small apertures, but also because the percentage of open area is large enough to pass large quantities of water at a reasonable head loss. Finally, the use of stainless steel makes the cloth strong enough to withstand backwashing under pressure and fairly rough treatment, and should assure a long life.

The apertures in the fabric are comparable in size to the pore spaces in clean, uniform filter sand. The strainer removes only those particles larger than the apertures or large enough to be

TABLE 1

Effect of Prefilters on Secondary Filter Operation
(London Metropolitan Water Board)

Plant	Prefilters			Slow Sand Filters			
	No.	Area *sq ft*	Rate *gpm/sq ft*	No.	Area *acres*	Capacity *mgd*	Rate *mgd/acre*
With prefilters							
Hampton	32	43,680	1.53	38	41.01	96	2.34
Kempton Park	24	9,984	3.00	12	9.00	43	4.80
Walton	18	7,488	2.67	6	4.92	29	5.85
Stoke Newington	12	10,800	2.31	9	9.04	36	3.98
Avg							4.24
Without prefilters							
Barnes and Barn Elms*	9	2,592		20	24.19	41	1.69
Surbiton				24	26.11	48	1.84
Lee Bridge				25	24.75	49	1.99
Others				27	20.53	36	1.75
Avg							1.82

* A portion of the water passes through primary filters.

* Glenfield and Kennedy, Ltd., Kilmarnock, Scotland.

caught by a mat built up on the strainer. As it is washed continuously, a part of the drum is always free from any matting and at least some of the particles smaller than the apertures will pass through the screen. On the other hand, sand filters remove particles and colloidal material very much smaller than the pore spaces between the sand grains. This difference is of fundamental importance, and the limitations of the microstrainer must be recognized.

Raw water enters the inside of the drum and passes outward through the fabric, which is usually protected by a pilot screen, inside and out. Straining rates depend upon the raw-water quality, ranging from 4 gpm per square foot for heavily contaminated waters to 15 gpm per square foot for good-qual-

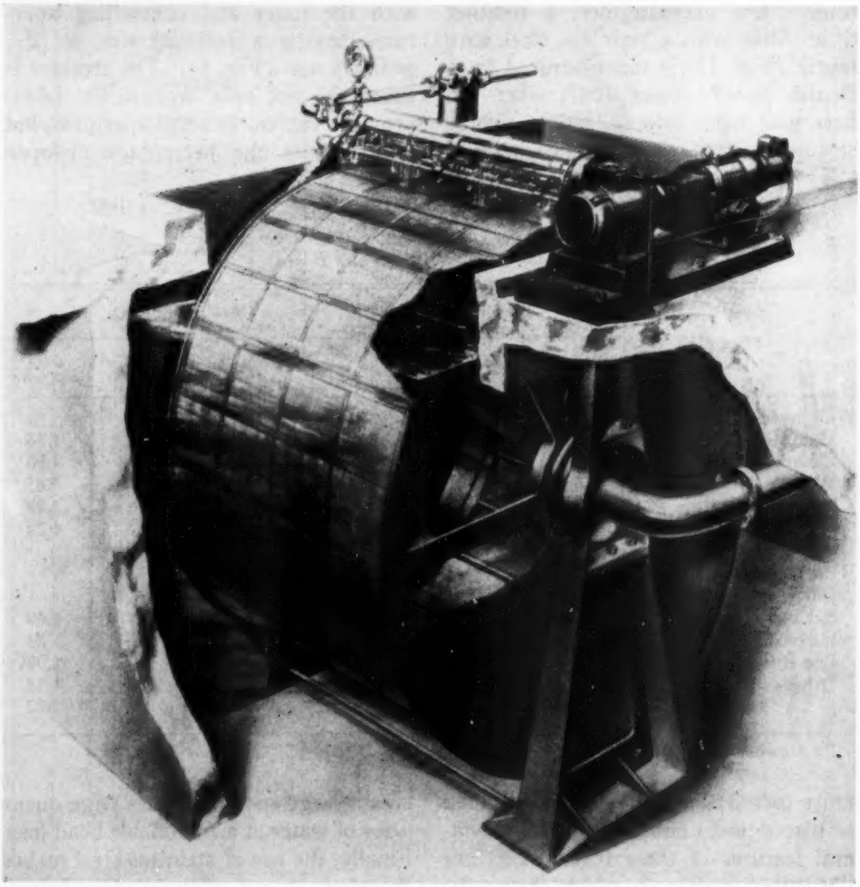

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Fig. 2. Cutaway Drawing of Microstrainer

ity supplies from impounding reservoirs. A standard microstrainer, 7½ ft in diameter and 5 ft wide, will strain 3 mgd under ordinary conditions.

The drums are rotated by multispeed drives at a circumferential velocity of 12–50 fpm. The head loss is usually less than 6 in. through the fabric itself and not more than 12–18 in. through the entire straining plant, including influent and effluent piping. Backwash is applied through jets at a pressure of 5–10 psi. The quantity of wash water for a strainer operating near capacity ranges from approximately 0.5 to 1.5 per cent of the total water filtered.

It will be noted that the Kempton Park plant, containing four strainers with a capacity of 3 mgd each, occupies a space of only 44 by 16 ft. The strainers were installed in parallel with the prefilters to obtain comparative operating data. The piping was arranged to supply one slow sand filter (No. 1) from the microstrainers, while two filters (No. 4 and 5) fed from the prefilters were selected for observation and comparison.

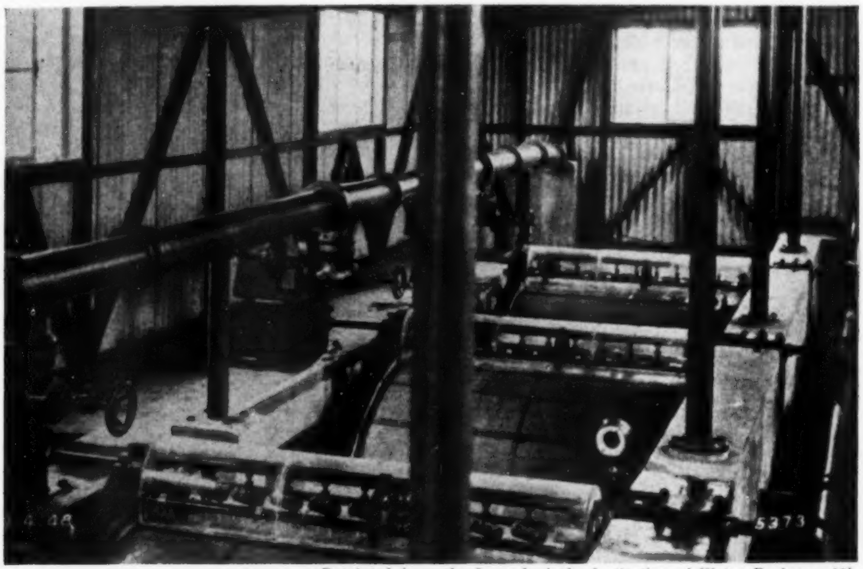

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Fig. 3. Kempton Park Microstrainers

Three of the four microstrainers at the Kempton Park Works are visible in the photograph. The microstrainer diameter is 7½ ft and its width is 5 ft.

Performance

The comparative performance of the microstrainers and prefilters at Kempton Park is indicated by the data in Table 2. For the whole period of test, the average rate of filtration was approximately 10 per cent higher in the filters taking prefiltered water. The two sand beds following the prefilters were not cleaned as often as that fol-

TABLE 2

Comparative Effects of Microstrainers and Prefilters on Secondary Filter Operation (Kempton Park Works)

Secondary Filter Operating Data	4-yr Period*		Period of Best Operation With 2-in. Head Loss†		Operation at 5-in. Head Loss‡	
Pretreatment	Prefilters	Microstrainers	Prefilters	Microstrainers	Prefilters	Microstrainers
Slow sand filter No.	4 & 5	1	4 & 5	1	4 & 5	1
Total run—*days*	1,257	1,116	113	114	204	202
No. of times bed cleaned	37	50	3	3	7	8
Water filtered per acre cleaned —*mil gal*	239	144	274	250	202	176
Avg filter rate—*mgd/acre*	7.0	6.5	7.1	6.6	6.9	7.0
Avg amount of sand skimmed per cleaning—*cu yd*	76	88				

* March 1948–March 1952, excluding the period August–November 1949, when low water prevented the operation of both prefilters and microstrainers.
† November 1949–March 1950; four microstrainers in use.
‡ April–December 1952; two or three microstrainers in use.

lowing the microstrainers, and, in overall performance, the quantity of water filtered per acre cleaned was considerably greater for filters No. 4 and 5 than for filter No. 1. The results obtained with the microstrainers for the entire 4-year test period were affected adversely by improper operation of filter No. 1 during the first few months. The exact cause of the difficulty has not been determined but is believed to have been within the slow sand filter itself, independent of the microstrainers. The relatively better performance of the microstrainers following this initial difficulty is indicated by the remainder of Table 2. Wash water consumption varied between 1 and 4 per cent for the prefilters and between less than 0.5 and 4.5 per cent for the microstrainers.

TABLE 3

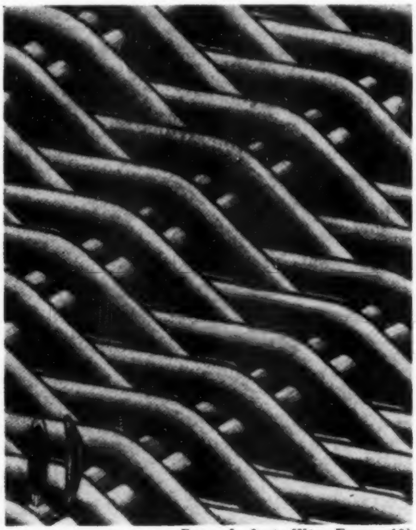
*Comparative Effects of Microstrainers and Prefilters on Water Quality**

Item	Impounded Water	Microstrained Water	Primary Filtrate	Secondary Filtrate	Amount Removed *per cent*
	ppm				
Ammonia nitrogen	0.11	0.11	0.02	0.01	91
Albuminoid nitrogen	0.16	0.14	0.14	0.10	38
Oxygen absorbed (3 hr at 27°C)	1.68	1.56	1.54	1.25	26
Turbidity (silica scale)	3.7	3.2	1.7	0.6	84
Color	57	55	53	42	27

* Average for 5-year period, 1948–52, at Kempton Park Works.

This comparison may be misleading. The straining plant is rated at 5–6 in. of head loss, but during most of the test it was operated at less than full capacity with a loss of only 1–2 in. As the quantity of wash water is fairly constant, the percentage is relatively high when the plant is operated at less than capacity.

The comparative effect on the physical and chemical characteristics of the



From J. Inst. Wtr. Engrs. (2)

Fig. 4. Microstrainer Fabric

A typical diatom (Cymbella) *is shown against the fabric in the lower left-hand corner of this isometric drawing.*

water is shown in Table 3. It will be noted that neither the prefilters nor the microstrainers appreciably reduced albuminoid nitrogen, oxygen absorbed, or color. The microstrainers had no effect on ammonia nitrogen and reduced turbidity only slightly, whereas both were reduced substantially by the prefilters. The final effluents, after passage through the slow sand filters, were identical, however.

The microstrainer will not remove color or colloidal material and has little effect on turbidity unless it is combined with mat-forming substances such as algae. Alum floc acts more like a liquid than a solid and passes through the wire mesh. The removal of large-size plankton is more nearly complete than that of small organisms. Table 4 shows the percentage removal as indicated by samples collected at the Barrow Works

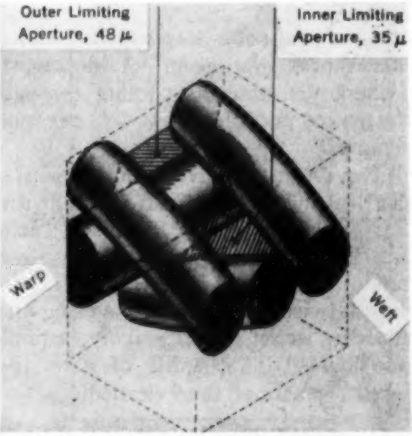


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Fig. 5. Limiting Apertures

The outer and inner limiting apertures of the microstrainer fabric shown in Fig. 4 are defined in this drawing.

of the Bristol, England, Waterworks Co. Figure 6 compares the algae population before and after straining over a period of several years.

The greater percentage removal accomplished after a mat has built up on the straining fabric is shown by data obtained at the Barrow plant: samples taken near the point of entry of the drum into the water indicated 43 per

TABLE 4

Removal of Algae

Organism	No. per Milliliter		Organisms Removed *per cent*	Estd. Size *μ*
	Before Straining	After Straining		
Synedra	7,500	2,000	73	10×150†
Asterionella	12,800	450	96	3× 60†
Fragilaria	115*	0	100	4× 40†
Stephanodiscus	740	470	36	15× 60
Unidentified small diatom	670	380	43	
Filaments of *Gleotrichia*	1,000	670	33	
Tetraspora	1,200	950	21	3–12

* Number of colonies.
† Size of elements; a complete, unbroken organism comprising several elements is considerably larger.

cent removal (of *Synedra*), while those taken near the point of departure (where the water is passing through the matted portion) showed 98 per cent removal.

The effect of microstraining on the performance of slow sand filters at the Barrow Works is summarized in Table 5. The filtration rate through slow sand filters using strained water was almost twice the rate in filters using unstrained water. Furthermore, straining doubled the quantity of water filtered per acre of sand cleaned.

Operating Difficulties

A number of operating difficulties have been encountered:

Air binding has been caused by the pilot fabrics. This difficulty has been eliminated by using coarse pilot fabrics to prevent the formation of a stable water film across the openings.

Some kinds of algae, particularly *Tribonema,* found extensively in the Thames River water, form a sticky mat, which clings tenaciously to the underside of the straining fabric. This difficulty has been eliminated by removing the inside pilot fabric.

Unstable waters likely to deposit calcium carbonate may clog the screens. Occasional application of hydrochloric acid is necessary to dissolve the calcium carbonate. Continuous neutralization of the water has not been required.

TABLE 5

Effect of Microstraining on Filter Performance
(Barrow Works, Bristol Water Works Co.)

Year	Filters Taking Strained Water		Filters Taking Unstrained Water	
	Water Filtered per Acre Cleaned *mil gal*	Approx. Avg Filter Rate *mgd/acre*	Water Filtered per Acre Cleaned *mil gal*	Approx. Avg Filter Rate *mgd/acre*
1947	182	3.26	75	1.78
1948	156		83	
1949	158	3.52	70	1.82
1950	148	3.55	83	2.01
1951	161	3.35	97	2.07

Slime formations have been troublesome in some waters but can be controlled by periodic heavy chlorine doses.

At the Barrow plant, the strainers occasionally have been clogged with clay, apparently supported by a mat of algae. The clay can be removed by increasing the wash water jet pressure.

Costs

The comparative construction costs of microstrainers and other types of filters are illustrated by the data in Table 6. The cost of a 9-mgd plant at Barrow may be broken down thus:

Substructure, pipe work, and drainage (reinforced concrete, excavation mostly rock, 50 yd of pipe)	$15,400
Superstructure (steel frame, asbestos siding, and cinder block)	4,760
Microstrainers (3 at 3 mgd)	25,480
Metering	3,920
Total	$49,560
Cost per mgd	5,500

Accurate operating cost data are not available, but the microstrainer should compare favorably with the prefilters. A microstrainer has a much lower head loss than a prefilter, needs almost no attendance, and does not require an unduly large quantity of wash water. The equipment is ruggedly built, with the stainless steel wire fabric a substantial cost factor. Apparently wire has stood up well for several years in existing installations. Unless it proves necessary to replace the fabric at frequent intervals, the maintenance costs should be nominal. The Metropolitan Water Board and several other water works operators have decided that, although the performance of the microstrainer does not quite equal the results obtained with prefilters, the expected cost savings are sufficient to favor it.

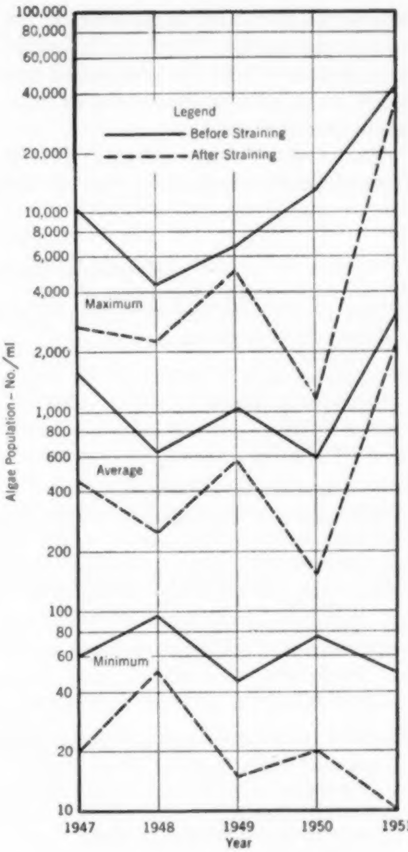

Fig. 6. Algae Removal

The graphs show the algae population before and after straining. The 1951 results were affected by an invasion of small diatoms (Synedra rumpens), *at least 75 per cent of which passed the strainers.*

Other Uses

The microstrainer has been used in water works practice for purposes other than prefiltering ahead of slow sand filters. Thus, several plants, up to 3–4-mgd capacity, which filter industrial and public water supplies with micro-

strainers alone have been built or are under construction. Such use is limited to situations where the removal of turbidity or color is unnecessary or relatively unimportant.

The Colne Valley Water Co. in Hertfordshire, England, plans to use the microstrainer ahead of coagulation-softening and filtration in an unusual arrangement. A 29-mgd water supply, taken directly from limestone wells during most of the year, will be softened in a high-rate upflow tank and then filtered. During the summer months and in droughts lasting 40–50 days, the yield of the wells is expected to drop to 14 mgd. To make up the deficiency at such times, water is to be drawn from an open 500-mil gal reservoir, filled from the wells in wet weather when there is surplus water. The clear well water, exposed to sunlight and rich in phosphorus and silica, is expected to support algae growth that might interfere with normal treatment. Therefore, the water from the reservoir will pass through a microstrainer before going to the softening plant. It is

TABLE 6

Comparative Construction Cost Estimates

Ashford Common Works, London area (108-mgd capacity)	
Conventional prefilters	
Total cost	$1,568,000*
Cost per mgd	14,500
Microstrainer plant	
Total cost	1,066,800†
Cost per mgd	9,900
Fairmilehead Works, Edinburgh‡	
Additional slow sand filters (6.3-mgd capacity)	
Total cost	246,000
Cost per mgd	39,000
Conventional prefilters (18.9-mgd capacity)	
Total cost	314,000
Cost per mgd	16,600
Microstrainers (18.9-mgd capacity)	
Total cost	112,000
Cost per mgd	5,900
Roseberry Works, Edinburgh (3.6-mgd capacity)	
Slow sand filters (rated at 3.6 mgd/acre)	
Total cost	162,000
Cost per mgd	45,000
Coagulation and rapid sand filters	
Total cost	168,000
Cost per mgd	46,700
Microstrainers plus smaller slow sand filters	
Total cost	109,000
Cost per mgd	30,300

* Includes $448,000 for "plant and auxiliaries" and $1,120,000 for "building and civil engineering works."
† Includes $714,000 for "plant and auxiliaries" and $352,800 for "building and civil engineering works."
‡ Cost figures are for alternative methods of adding 6.3-mgd capacity to present 12.6-mgd plant, which now consists of slow sand filters with no prefiltration.

believed that abnormal algae loads can be avoided and a fairly constant quality of water delivered to the softening plant.

American Applications

The author is uncertain whether microstraining equipment will have many applications in municipal water works in the United States. Most of the American slow sand filters are in the northeastern part of the country where occasional turbidity is likely to be more troublesome than algae. Presettling, sometimes with a coagulant, is often provided ahead of slow sand filters, and the rates in many such American plants are already equal to or greater than the highest rates employed in Great Britain. Normally, if conventional coagulation and rapid sand filtration are required, there is little to be gained by microstraining. Coagulation and sedimentation will eliminate most of the organisms and particles that a microstrainer can remove, while the material that does escape will be caught on the filters.

In 1951 Sanchis and Merrell (*5*), of the Los Angeles Dept. of Water and Power, described studies on diatomaceous earth filtration for the removal of algae in the open distribution reservoirs of the city. The authors stated that chlorination yielded safe water but that, at some future time, more complete treatment might be indicated. Because of the particular circumstances, the small space requirements of the diatomaceous earth filters and their ability to operate under high pressure were attractive features. Sanchis and Merrell reported microscopic-organism densities ranging from 20 to 6,000 areal standard units per milliliter. Most of the organisms were fairly large, the kind most susceptible to removal with a microstrainer. This situation is mentioned only to illustrate the type of conditions under which microstraining might be useful. It is recognized that the special problems at Los Angeles might preclude the use of the microstrainer entirely.

Some communities using unfiltered water occasionally suffer from heavy algae growths. These could be helped by microstrainers, but complete removal of the algae is not likely to be obtained. The microstrainer certainly would not eliminate the "muddy water" common in unfiltered supplies. Possibly, the addition of a fibrous material or filter aid might give good results, but this complication would detract from the basic simplicity of the process.

For those communities with slow sand filters sometimes harassed by heavy algae growths, the microstrainer does have a definite advantage, as proved by its success in Great Britain.

Acknowledgment

The author is indebted to the following individuals in England for some of the data presented in this paper: H. F. Cronin, Chief Engr., Metropolitan Water Board, London; E. C. Green, Chief Engr., Colne Valley Water Co., Hertfordshire; R. W. M. Melvin, Gen. Mgr., Bristol Waterworks Co., Bristol; and P. L. Boucher, Chief Civ. Engr., Glenfield and Kennedy, London.

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Discussion

A. A. Kalinske

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Microstraining was originally conceived for the specific purpose of filtering out planktonic invaders, especially algae, from impounded water supplies ahead of slow sand filters. The time between cleanings of slow sand filters can be increased considerably by the use of this method. Because, in the United States, the number of water plants employing slow sand filtration is very small indeed, applications of microstraining for this purpose are not very extensive. In general, it might be said that microstraining has a place in the art of water treatment for the removal of plankton and microscopic debris of various types from industrial water that has little colloidal turbidity or color and requires no other treatment. It is doubtful whether there are many water supplies that need only microstraining and chlorination to be satisfactory for human consumption.

If a raw water is turbid and colored and contains colloidal impurities, microstraining can usually do little but remove microscopic and macroscopic suspended matter. Bacteriological considerations apart, the main problem, turbidity and color, still requires the addition of chemicals for precipitation and coagulation, sedimentation with sludge removal, and rapid sand filtration. It is also quite difficult, and not very economical, to use microstraining on very dirty waters. Usually sedimentation and chemical treatment are essential before any filtration process can be employed for such waters.

Microstraining is generally not suitable for the removal of chemical floc from treated water. The amount filtered out depends upon the physical state of the floc, which, in water treatment, appears to be more liquid than solid and, hence, tends to flow through the fabric apertures quite readily. Studies on this problem are in progress, but at present the possibility of using microstrainers instead of rapid sand filters does not look very promising.

An application of microstraining that is not of direct concern to the water works engineer but nevertheless deserves mention is the additional clarification of sewage plant effluents. As such effluents are often discharged into small streams, further polishing after clarification is desirable, particularly if the effluent must be chlorinated. Significant reductions in suspended solids and biochemical oxygen demand can be achieved. At an English installation of this kind, suspended solids in the effluent have been reduced from 30 to 10 ppm and the biological oxygen demand from 25 to approximately 10–15 ppm.

Chicago Pilot Microstrainer

A pilot microstrainer was operated on raw Lake Michigan water at the Chicago South Dist. Filtration Plant for approximately 1 year, observations

being made on plankton removal, turbidity, filtrability index,* and other items. The pilot microstrainer had microfabric mounted on a drum with a diameter of 2½ ft and a total length of 2 ft. The rate of flow through the microstrainer was kept between 100 and 200 gpm, depending on the character of the water, as the maximum loss of head across the filtering fabric was never allowed to exceed 6 in.

Figure 7 shows the monthly average plankton population in the raw water and the average amount removed by the microstrainer each month for 13 months. The microstrainer removed an average of approximately 82 per cent of all the plankton in the raw water. Approximately 86 per cent of the three major types, *Tabellaria, Fragilaria,* and *Asterionella* (diatoms), was eliminated. The removal of turbidity, measured on the silica scale, amounted to approximately 20–50 per cent. Because turbidity in Lake Michigan water is of a very fine colloidal nature, it is not expected that much of it could be removed by the microstrainer.

There appeared to be some correlation between turbidity measurements and the filtrability index, especially during periods of relatively high turbidity in the lake water. For a turbidity of 50 ppm, the filtrability index was 1.0; for 25 ppm, 0.5; and for 10 ppm, 0.2. This relationship tended to vary from season to season as the character of the turbidity and the amount of plankton changed, implying that turbidity measurements are not of great value in indicating the filtrability of a particular water. For example, at one time the raw-water turbidity was 3.7 ppm and the strained-water turbidity was 3.2 ppm, a reduction of only approximately 13.5 per cent. The filtra-

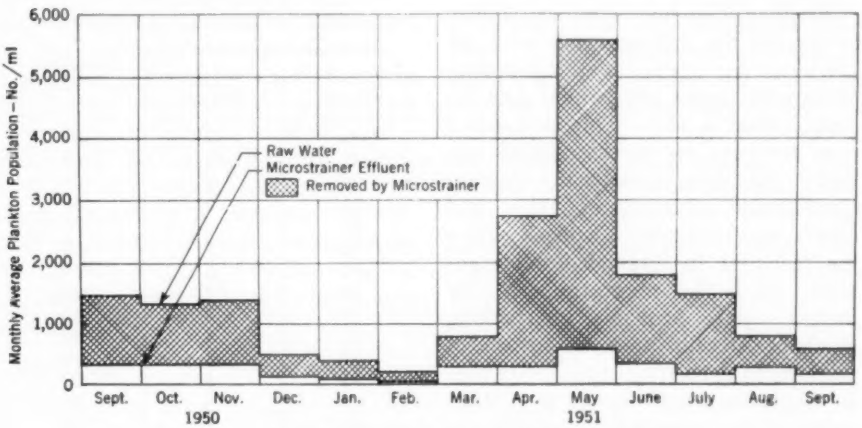

Fig. 7. Monthly Averages of Plankton Removal

The graph shows the monthly average plankton population and removal at the Chicago pilot microstrainer.

* This term, recently introduced in England, may be defined as a measure of the rate of increase in hydraulic resistance of a filter per unit volume of water filtered through a unit area at a constant filtration rate (*1*).

bility index, however, was 0.169 for the raw water and 0.042 for the strained water, a reduction of 75 per cent. In general, the reduction in filtrability index with the microstrainer tended to coincide somewhat with the reduction in the number of plankton. A sample of raw water at Grand Rapids, Mich., taken in July 1952, had a turbidity of 2 ppm and a filtrability index of 0.416, extraordinarily high for such a clear water.

Other Pilot Installations

Another pilot microstrainer, similar in size to the one operated on Lake Michigan water, was set up at a central Wisconsin paper mill which gets its supply from a lake. This lake water does not have too much colloidal turbidity but does occasionally contain considerable amounts of algae and other organic matter. Table 7 shows the reduction in suspended solids obtained with the microstrainer. No facilities were available for making plankton determinations, and suspended solids were determined gravimetrically. As might be expected, the percentage reduction varied significantly with the character of the solids.

A similar pilot plant has been set up at the Baltimore, Md., Sewage Disposal Plant. The unit was first installed to filter the final clarifier effluent. Test results indicated an average reduction of 40 per cent—from approximately 20 to 12 ppm—in suspended solids. A 50 per cent reduction—from 20 to 10 ppm—in biochemical oxygen demand was obtained. Some difficulty was encountered with clogging of the fabric by microscopic growths. Periodic cleaning with a solution of chlorine is said to prevent this condition, according to experience in England.

Conclusion

Investigations indicate that the application of the microstrainer to water treatment in the United States is very limited. Most of the surface waters in this country require some sort of chemical treatment for removal of turbidity and color, and the microstrainer is not a substitute for rapid sand filtration for final polishing. Chemical treatment and rapid sand filtration are desirable even for relatively clear waters, especially when used for human consumption, because of the large removals of bacteria and various protozoa obtained with such treatment. Of course, if a water is used only for industrial purposes and the removal of plankton and various macroscopic debris is the only treatment necessary, the microstrainer might be indicated.

TABLE 7

Daily Average Reduction in Suspended Solids

Suspended Solids—*ppm*		Reduction *per cent*
Influent	Effluent	
29	12	59
28	10	64
26	8	69
24	9	54
25	6	76
16	5	69
16	6	63
29	2	93
28	5	82
35	4	89
37	4	89
35	6	83
49	8	84
48	5	89
31	10	68
33	5	85
22	6	73
21	7	67

Again the microstrainer has only limited value as an adjunct to rapid sand filters, because algae troubles in surface water usually occur for just a few weeks each year, as in Lake Michigan supplies. It is very doubtful whether a large investment in microstraining would be justified under such conditions. Moreover, in small lakes and reservoirs, algae growths can often be controlled by other means, either chemical or physical. There have also been indications that plankton organisms, which are responsible for drastically shortening the runs on rapid sand filters, can largely be removed by enmeshment in the slurry pool or blanket of modern solids-contact clarification units. Everything considered, one is forced to the conclusion that microstraining as developed and used in England has extremely restricted application for municipal water treatment in the United States, and its use even for industrial water does not look very promising.

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Arthur W. Consoer

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For almost a year the writer has been of the opinion that microstraining may well fill a pressing need at water filtration plants on the eastern shore of Lake Michigan, many of which experience short filter runs. At one plant, in 1951, there were 48 days on which the filter runs fell below 20 hours, and 13 days on which they were under 10 hours. In 1952, on 62 days, the runs dropped below 20 hours; and on 10 days, below 10 hours. At a nearby plant, in 1951, 50 days showed filter runs of less than 20 hours; and 12 days showed runs below 10 hours. In 1952, there were 43 days when the runs were below 20 hours, and 20 days when they were below 10 hours.

In order to eliminate operating difficulties occasioned by low filter runs and diminished filter rates due to the incidence of algae in the raw water, it is important to determine from reliable statistics just how much the capacity of the filter plant is actually affected by this condition. It is particularly important to learn whether the algae troubles occur simultaneously with high pumping rates. The details of any complete shutdowns due to extraordinary concentrations of algae above the filter sand are also necessary information. When such data have been assembled, it will be possible to appraise the suitability of microstraining for American water filtration plants.

Where intermediate sewage treatment is needed, microstraining has been found useful in Great Britain and may be equally useful in the United States. Likewise, microstraining may have considerable value in preparing certain types of raw water for industrial use. There is a possibility that effluents from sewage treatment plants may be clarified sufficiently by microstraining to render the water fit for some industrial uses at a lower cost than is involved in alternative sources of supply.

Stationary Storage of Liquid Chlorine

By A. S. Woodard and L. L. Hedgepeth

A paper presented on May 11, 1953, at the Annual Conference, Grand Rapids, Mich., by A. S. Woodard, Chief Engr., Central Eng. Dept., Pennsylvania Salt Mfg. Co., Philadelphia, and L. L. Hedgepeth, Staff Technical Consultant, Calco Chem. Div., American Cyanamid Co., Bound Brook, N.J.

THIS paper deals with the technical principles pertaining to the storage of liquid chlorine (liquefied, anhydrous, elemental chlorine) in permanently mounted stationary vessels at consumers' plants. It has been the practice to use chlorine shipping packages as storage vessels for consumer reserve supplies. Recently it has been suggested that an answer to one of the perplexing problems of chlorine reserves for water purification and sewage treatment plants might be found in utilizing stationary vessels.

This interest in stationary liquid-chlorine storage has resulted from a consideration of ways and means to insure an adequate reserve supply for public health purposes. During World War II, and for a hectic period following the outbreak of the Korean War, unprecedented shortages of chlorine developed in the United States, with the result that some water and sewage plants had difficulty in securing sufficient quantities of chlorine. Management became gravely concerned and some ad hoc investigating committees were formed in late 1950. Relief was obtained through a combination of pressure from the public health field, cooperation from the chlorine manufacturers, and the use of material allocation powers by the federal government.

The emergency committees have now been consolidated into two groups: [1] the Joint Committee on Chlorine Supplies, representing the Conference of State Sanitary Engineers, the AWWA, the Federation of Sewage and Industrial Wastes Assns., and the U.S. Public Health Service; and [2] the Public Health Advisory Committee, created by the Chlorine Institute, Inc., with advisory members from the U.S. Public Health Service and the affected professional associations, including the AWWA. A function of these committees is to consider and recommend appropriate action to insure an adequate and continuous supply of chlorine for water purification and sewage disposal plants and for other public health needs.

One of the problems presently being studied is the retention of shipping containers in users' plants for periods which the chlorine suppliers consider objectionably long and which the consumers in the water and sewage field consider necessary to maintain an adequate chlorine reserve for their essential facilities. The authors recognize that uninterrupted operation of these utilities is a primary public health necessity and that an adequate supply of chlorine must be provided for them. As this aim might be accomplished in more than one way, and as practices

at one plant may be entirely unsuited to another, the authors make no recommendation on storage methods for specific plants. They do feel, however, that, under the right conditions and with proper precautions, stationary storage of liquid chlorine is practical and feasible.

Properties of Liquid Chlorine

An intelligent approach to the consideration of the storage of any material requires first that data on its properties be assembled. For chlorine, this information is readily available in the published literature and conveniently obtainable from the chlorine producers or from the Chlorine Institute manual (*1*). Only the essential data will be presented in this paper.

Liquid chlorine is a clear, amber-colored liquid with a specific gravity of approximately 1.5. Its specific heat is 0.223 Btu per pound per degree Fahrenheit and its latent heat of evaporation is 110 Btu per pound at 70°F. At −30.1°F, (the boiling point) one volume of liquid chlorine is equivalent to 462 volumes of gaseous chlorine. Although this ratio is not too surprising for a compressed gas, it is nevertheless apparent that a very small quantity of liquid chlorine makes a substantial volume of gas. Because gaseous chlorine is approximately 2.5 times as heavy as air, it tends to accumulate in low places and is slow to diffuse into the air. Gaseous chlorine is, of course, liquefied by application of pressure at reduced temperature. At −30.1°F, the vapor pressure of chlorine is at atmospheric pressure or 0 psi gage; at 68°F, the pressure is 81.9 psi gage; and at 212°F, it is 539 psi gage. This relationship is shown in Fig. 1.

Figure 2 shows the temperature-density relation of liquid chlorine; the rapid decrease in density with increasing temperature will be noted. This characteristic is most important, because the temperature-pressure relationship applies only when a vapor space is present. Any rise in the temperature of liquid chlorine when the vapor space is exhausted will result in the development of hydrostatic pressure of infinite limit and the rupture of the tanks. Consequently, Interstate Commerce Commission regulations limit the loading of chlorine containers to 125 per cent by weight of the water capacity at 60°F. Practically interpreted, this means that a cylinder of 120-lb water capacity at 60°F may be legally loaded with not more than 150 lb of chlorine.

As shown in Fig. 3, at a temperature of 60°F and under these loading conditions, the container is 87.8 per cent full of liquid. The liquid volume increases with the temperature, however, until, at 153.4°F, the vessel is 100 per cent liquid full. A further increase of temperature will cause hydrostatic rupture of the tank unless safety devices are provided. These are usually spring-loaded safety valves for storage tanks and tankcars, and fusible vents for cylinders and ton containers.

At normal temperature, anhydrous chlorine, whether gaseous or liquid, can be handled in equipment fabricated from a variety of materials, including iron, steel, Monel, nickel, copper, brass, bronze, and lead. These materials are not seriously attacked by dry chlorine, but the presence of moisture will result in severe corrosion. Anhydrous chlorine at elevated temperature will attack metals. Chlorine, liquid or gaseous, is nonflammable and will not support combustion in the usual sense. Gaseous chlorine will, however, support the combustion of certain materials, such as combustible organics and finely divided cork, under normal temperature,

and steel under elevated temperature. It reacts with oil at ordinary temperatures to form waxes that will gum feeding equipment.

The physiological effects of chlorine are not covered in this paper, but it is well to note that its odor is detectable at 3.5 ppm in air, a nonhazardous concentration for ordinary exposures. At higher concentrations, danger may be present. For example, throat irritation may be experienced at 15 ppm, and a period on the order of 30 min is the maximum safe exposure for concentrations of 40–60 ppm.

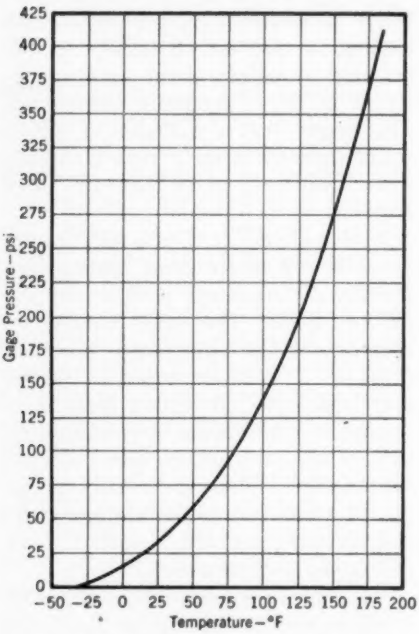

Fig. 1. Temperature-Pressure Curve

Gas and liquid exist in a state of balance for all conditions of temperature and pressure whose values meet on the curve.

Storage Vessels

Pressure vessels for the storage of liquid chlorine would normally be of the horizontal type with dished heads. They must be fabricated in accordance with the applicable code requirements of the state and city in which they will be used. Minimum standards of fabrication should be the ASME "Code for Unfired Pressure Vessels" (*2*).

As an illustration, the ASME code may be applied to the design of a horizontal storage tank to contain a maximum loading of 55 tons of liquid chlorine. Assuming that the tank has a 90-in. ID and is 30 ft 3 in. long on the straight side and 34 ft long including elliptical heads, it would have a volume of 1,447 cu ft. Based on the accepted practices under the ICC regulations, the chlorine capacity would be $1{,}447 \times 62.4 \times 1.25 = 112{,}866$ lb. With a design pressure of 250 psi, equivalent to the vapor pressure at 142°F, carbon-steel plate having the specification number SA-212, Grade B, is selected from Table UG-23 of the 1950 ASME code. This material has a minimum tensile strength of 70,000 psi and a maximum allowable working

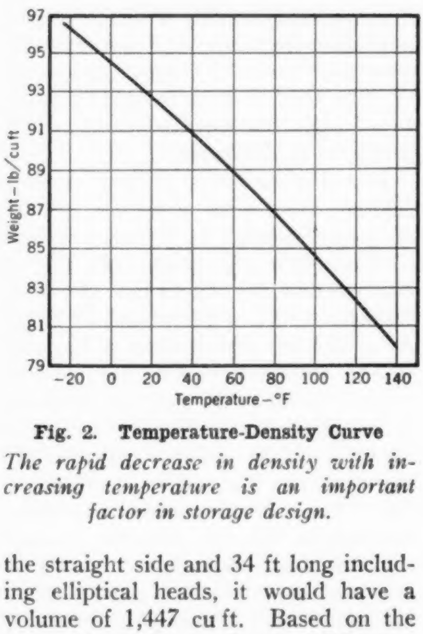

Fig. 2. Temperature-Density Curve

The rapid decrease in density with increasing temperature is an important factor in storage design.

stress of 17,500 psi for metal temperatures not exceeding the range $-20°F$ to $+658°F$. The shell thickness, computed in accordance with Par. UG–27, is 0.730 in. Added to this is a $\frac{3}{16}$-in. corrosion allowance, establishing a shell thickness of $\frac{7}{8}$ in. Using a standard elliptical head of 2:1 ratio, the head thickness, calculated in accordance with Par. UG–32D, is 0.64 in., which, with the same allowance of $\frac{3}{16}$ in. for corrosion, would give a head thickness of

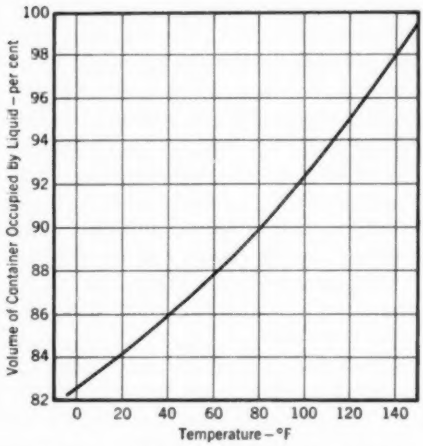

Fig. 3. Volume-Temperature Curve

The percentages apply to containers carrying the legal maximum load permitted by ICC regulations.

$\frac{7}{8}$ in. The tank would be electric fusion welded, the welds being continuous on both sides.

For the material specified, SA–212B, the code requires stress relief and radiographic examination only if the thickness is at least 1 in. Because of the dangerous nature of the contents, the authors recommend, nevertheless, that the vessel be both stress relieved and radiographed.

To the basic tank must be added appropriate nozzles for access for inspection, safety valves, chlorine inlet, chlorine outlet, chlorine vent line, compressed air line, and tank pressure gage. The arrangement used is optional with the designer, but there is some advantage in grouping several items on the cover plate of a large nozzle or manhole.

It is recommended that the completed tank be subject to a final inspection at the time of the hydrostatic test and be provided with a code stamping. The design of the tank must, of course, take into account its support, with stiffening rings employed where required.

Insulation of the tank is recommended to avoid sweating and resulting corrosion during frequent periods of low temperature and to minimize the effect of ambient and radiant heat on the storage pressure. Adequate insulation is furnished by 4-in. cork board.

Appurtenances

In general, pipelines for handling liquid chlorine or dry gas should be fabricated from extra-heavy black iron pipe. Joints should be welded or flanged, using tongue and groove flanges. The standard ammonia type of flange is preferable, as its use permits easy inspection and repair of lines. A minimum number of fittings is desirable; when necessary, fittings of forged steel will serve. Gaskets should be made of lead containing 2–3 per cent antimony or of compressed asbestos. Rubber gaskets are not suitable.

Long chlorine lines should be protected with a valve at each end and should be provided with a liquid expansion chamber, so that, if both valves are closed and the line is exposed to increased temperatures, the expansion chamber will provide for the increased volume and prevent hydrostatic rupture. A standard 100-lb chlorine cylinder, inverted, mounted vertically, and

connected into the line at its highest elevation, serves very well for most typical requirements. Unusual conditions may warrant multiple expansion chambers.

Only valves designed for chlorine service should be used. The standard Chlorine Institute angle valve employed on ton containers can be adapted to many installations. For general service, however, valves of forged-steel construction with Monel trim are preferred. Plug valves with outside screw and yoke, flanged and bolted bonnets, screwed bodies, and deep stuffing boxes using graphite-asbestos rope packing give good service.

Gages for chlorine should be of the diaphragm type, designed for chlorine service. Their range should be 1.5 times the relief pressure of the safety valves. These likewise should be designed for chlorine service. The type most generally used is a spring-loaded reseating valve, constructed chiefly of steel and Monel and designed by the Chlorine Institute. It is provided with a protective mechanism that prevents chlorine from entering the working parts of the valve until operated by excess pressure.

Loading and Maintenance

The amount of storage capacity to be installed is an important consideration. The minimum capacity required equals the smallest single-unit car (16 tons), plus allowance for variation in scheduled arrival of cars. This allowance might be computed as the daily consumption of chlorine times the largest number of days between the placement of an order and the receipt of the chlorine. Relatively high rates of consumption may make it desirable to be able to receive the 30-ton cars, or the maximum-size single-unit cars (55 tons). Finally, capacity may be established strictly on the basis of a predetermined policy to maintain a minimum stock of chlorine (in terms of number of days, weeks, or months) on hand at all times. As the size of the chlorine tankcar to be used and the shipping time required are factors best known to the chlorine producer, it is advisable to obtain his assistance in deciding on the amount of storage capacity to be provided.

Several considerations indicate the desirability of having the storage capacity in the form of two tanks of identical proportions. First, it is necessary that the pressure in the storage tank be reduced below that of the tankcar (preferably to atmospheric pressure) before filling and kept lower, if a reasonable filling rate is to be maintained. With a single storage tank delivery to the point of consumption, uniform chlorination of the water will be difficult, if not impossible, during the filling operation. With two tanks, this difficulty is avoided.

Second, it is desirable, and necessary under the regulations for the maintenance of pressure vessels, to inspect the storage tanks at regular intervals. During the appreciable period required to prepare the tank for inspection and during the actual inspection itself, either a second storage tank or a tankcar will be needed to maintain a continuous flow of chlorine to the feeders.

Provision must be made for determining the contents of the storage tank. This is desirable for inventory purposes and is essential to avoid overfilling. Overfilled tanks run the risk of hydrostatic rupture or the opening of safety valves and the discharge of chlorine. Of the many possible solutions, none exceeds in simplicity and reliability the use of scale-mounted tanks. Unfortunately, this is probably also the most

costly means, a factor that should not, however, militate against its use.

Internal devices, including floats, buoyant tubes, and balanced diaphragms, although excellent in themselves, have a serious drawback in that the tank must be emptied to permit servicing. External devices that, in effect, serve to weigh the tank and contents avoid this difficulty. Representative of this group are the Taylor load elements.* When first cost is of serious moment and provision for adequate servicing is available, these can prove satisfactory.

The withdrawal of chlorine from the stationary storage tanks for use in the feeder is essentially the same as withdrawal from a tankcar. This matter will not be dealt with, as the recommended safe practices are well known to chlorine consumers and are described in publications issued by the Chlorine Institute and by chlorine manufacturers. Transfer from a tankcar to intermediate stationary storage does, however, involve additional problems, the solution of which is essential to the safe and satisfactory use of such tanks.

The stationary storage tank in use will be working at a pressure equal to the vapor pressure of the chlorine at the temperature prevailing, or at a higher pressure if "air padding" is used. ("Air padding" is the addition of moisture-free and oil-free compressed air to the vapor phase of the storage tank or tankcar.) It is, therefore, more than likely that, at the time it is desired to transfer chlorine from tankcar to storage, the pressure in the storage tank will be equal or so close to that of the tankcar that adequate unloading rates for the chlorine will be impractical. Thus, it is necessary to provide a means of venting chlorine gas (or chlorine and air mixtures) from the storage tank in order to lower its pressure and permit transfer. Such venting may be required during the entire transfer period.

Facilities must be available to absorb or otherwise dispose of the chlorine or chlorine-air mixture released during such venting. The nature of these facilities will, of course, vary with the conditions existing at the particular site. Under the most favorable circumstances, the gas might be vented to the consuming process without loss or additional equipment and expense. This procedure may not be practical in a water plant. Under the worst conditions, it might be necessary to provide equipment to absorb the gas in an alkaline solution circulating over a scrubbing tower properly designed to handle wet chlorine gas. Under other conditions, venting waste chlorine gas to a large sanitary sewer, or to an active, high smoke stack, may be the best and simplest solution. The importance of this matter cannot be overestimated, and the attendant problems in a particular situation may, in themselves, render stationary storage impractical for the water plant.

Movement of chlorine from stationary storage to the feeders during the filling operation is at best inconvenient and, depending on the pressure required, may not be feasible. Under such conditions, the need for two storage tanks is apparent. The use of bypasses, multiple-pressure-level operation, and other devices to get around this problem is, in general, unsatisfactory, as they tend to increase the complexity of maintenance and operation of the facility, and thus add to the hazards. The installation in a water plant must be amenable to simple, straight-

* A product of Taylor Instrument Co., Rochester, N.Y.

forward operating procedure. No water plant can risk a shutdown.

As mentioned earlier, air padding of the storage tank may be necessary to provide an adequate working pressure. The air used must be dry and free of oil. To avoid any possibility that chlorine will inadvertently enter other parts of the plant through connecting air lines, a small, separate compressor, used solely for this purpose, should be provided. The air should be dried in regenerative units containing activated silica gel or activated alumina yielding dew points of −50°F. Moisture will promote serious corrosion of valves and piping, as well as of the tank itself. To protect the air compressor and drier, check valves and stop valves must be provided in the air line to the tank, all of which are to be suited to dry chlorine gas service, as well as air.

A detailed description of the requirements and procedures for preparing the storage tank for inspection will not be given here. The inspection itself must conform to the codes of the area, which may affect the design. Provision must be made to permit removal of as much liquid chlorine as possible from the tank. Venting of chlorine gas remaining after the liquid is removed, with reduction of pressure to atmospheric, is necessary. Washing of the tank may be required, with attendant provision for continuous flushing of the tank to avoid local corrosion by chlorine water. Finally, the atmosphere in the tank should be rendered safe for personnel, although limited inspection by qualified experts using full protective equipment and suitable masks may be feasible.

Location of Tank

Certain general considerations warrant discussion. Even if every normal hazard is foreseen, human or equipment failure may still occur. The tank, therefore, should be as remote from buildings as practical, so that neither gas nor liquid may enter and perhaps trap the occupants. Similarly, the tank should never be near combustible buildings or material, because heat, as previously noted, will greatly accelerate the action of chlorine on the steel, with the possible release of the contents. The location of stationary storage tanks in or near areas of high occupancy should be avoided. Where such installations are necessary, more stringent safety measures must be adopted, such as the provision of a standby evacuated tank to permit transfer of the contents of the working tank in an emergency.

Conclusion

The elements of those practices for the safe storage of liquefied compressed gas that are applicable to the storage of liquid chlorine have been outlined on the basis of experience and information believed to be reliable. Space limitations preclude a complete listing of all requirements for safe storage practice, and those interested are urged to make a thorough study of the matter before undertaking the stationary storage of liquid chlorine. The authors neither approve nor disapprove of the storage of liquid chlorine in stationary pressure vessels at specific water purification and sewage disposal plants. Such storage installations should always be preceded by a comprehensive engineering study and a review of the pertinent facts by the management.

References

1. Chlorine Manual. Chlorine Institute, Inc., New York (1st ed., 1947).
2. Code for Unfired Pressure Vessels. Am. Soc. Mech. Engrs., New York (1950).

Fluoridation Costs and Problems

By H. Christopher Medbery

A paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by H. Christopher Medbery, Engr. of Water Purif., San Francisco Water Dept., San Francisco, Calif.

THE interest of water works men considering a fluoridation program either from choice or coercion centers around equipment, chemicals, and costs. Problems of design, installation, operation, and public relations are also involved. General information on the first two points is already available in the literature (*1*), and little can be added by the author other than specific details of the San Francisco, Calif., program. Costs are controversial, with opponents inclined toward high estimates and proponents leaning toward low estimates. Consequently, the statements made in this paper may be criticized by both. The problems discussed are those experienced at San Francisco.

Equipment

Feeders. Fluoride feeders may be generally classed as either solution or dry. The solution feeders commonly used are of the diaphragm type, similar to commercial hypochlorinating machines, and can be operated against either suction or pressure heads. Normal capacities range up to 0.8 mgd, but considerations of economy in selection of chemicals and the operational nuisance of large solution requirements will usually limit the amount to 0.5 mgd or less. The feeders may be operated manually, semiautomatically—that is, on a stop-start basis at any set rate—or fully automatically, with feed control from any conventional type meter. The solution type of feeder is best adapted to small installations.

Dry chemical feeders are normally designated as volumetric or gravimetric with the latter being divided into loss-in-weight and belt types. All the dry feeders have volume control but the gravimetric types possess added refinements. The loss-in-weight type maintains a feed rate in accordance with the travel of a poise on a scale beam balancing the chemical in the feeder hopper, while the belt type maintains a constant weight of chemical (for any set feed) on a specific length of belt normally traveling at a constant speed. Almost all types can be equipped for manual, automatic, or semiautomatic operation.

In general, the volumetric feeders are used for medium-size installations (0.5–2.5 mgd) and the gravimetric for the larger installations. One particular advantage of the loss-in-weight gravimetric type is the continuous chart record of the weight loss from the feeder hopper, which reflects the feed at all times.

Auxiliary equipment. Certain auxiliary equipment is necessary in many installations. As the flow of water must be known, a meter is required on the line, preferably at the station.

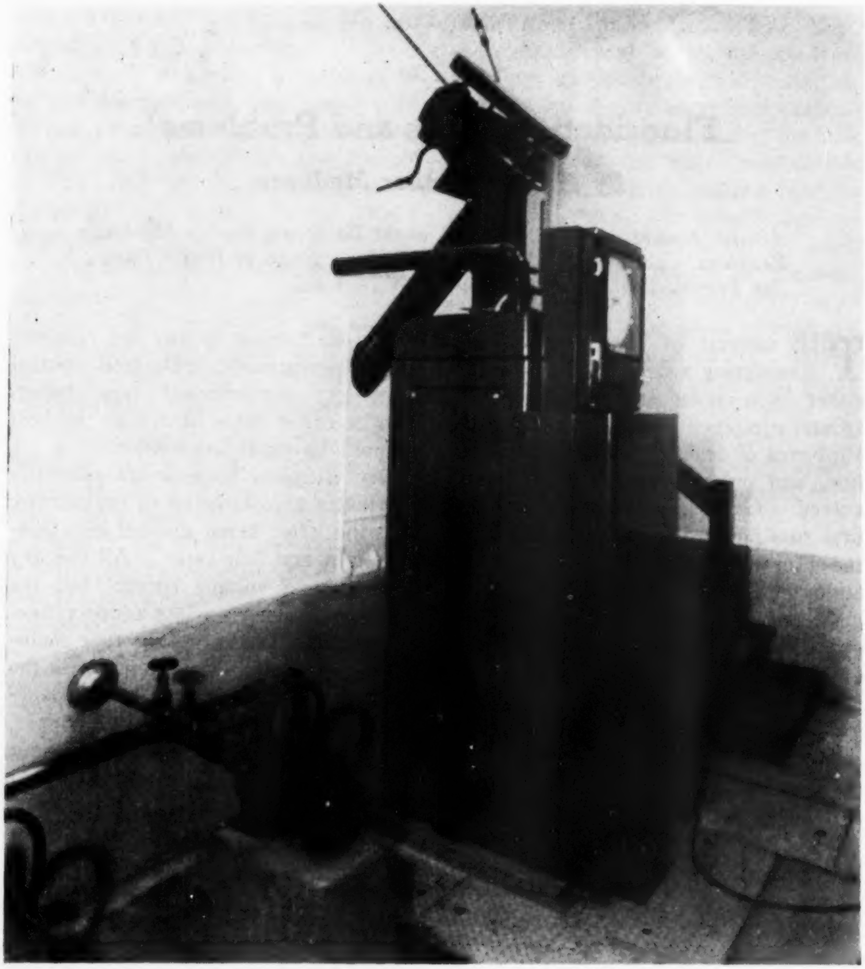

Fig. 1. Gravimetric Feeder

The feeder is of the loss-in-weight type and is automatically controlled. A portion of the inclined screw conveyor and the solution pumps can be seen.

Where the fluoride feeds into a line under pressure, either an ejector or an auxiliary pump must be used for handling the effluent from the solution pots of the dry feeders. If the back-pressure is under 10 psi, ejectors will probably be more desirable, while all-bronze or other corrosion-resistant pumps will likely be necessary for higher pressures. The actual selection will depend upon whether the water pressure available is sufficient to operate the ejector.

Dust collectors should be installed over the loading hoppers of the dry-

feed machines. Other safety devices include respirators and plastic or rubber gloves for the operators, with plastic sleeves and plastic or rubber aprons for those handling any appreciable amount of material.

After being taken out of the sacks, the dry chemical may be moved by any of the standard types of conveyors, provided it is made dusttight. If there are storage hoppers ahead of the conveying system, vibrators may be required to prevent arching.

San Francisco installations. Because the equipment recently installed in San Francisco, although all of standard make, has some features not common to most plants, it may be of sufficient interest to warrant description. Basically, each installation consists of a loss-in-weight gravimetric feeder that has a chart recorder and is automatically controlled by flow measurements on a venturi meter located a few hundred feet away. The feeder, with ejector or with all-bronze centrifugal pumps in duplicate, the electrical panel, and the chart-receiver are located in a room at ground level (Fig. 1). The loading hopper, supplying 80 per cent of the active storage, is located in the chemical storage room which is at truck bed height. The normal working active chemical storage is 14.3 cu ft, although an additional 20 per cent can be made available. Dust collectors are installed over each storage hopper, with the exhaust outside the building (Fig. 2). An inclined 6-in. screw conveyor, 10 ft long, carries the chemical from the storage hopper to the feeder hopper. The general schematic arrangement of the principal plant is shown in Fig. 3. A vibrator is mounted on the storage hopper to move the chemical into the conveyor. At a predetermined weight setting, the feeder switches into the load position, and the conveyor, dust collector, and vibrator, controlled through a timer, start simultaneously. The timer is set to permit loading for 1½ min, after which the conveyor, dust collector, and vibrator shut off. The feeder remains in load position for an additional 1½ min, permitting a final balancing of the beam, and then switches back into the feed position.

The volume of material handled by the screw will vary with the fineness and the amount in the storage hopper. With the very fine material received in the first shipment, the amount ranged from approximately 60 to 100 lb per minute. The coarsest material which the specifications will allow moved at the rate of approximately 200 lb per minute. Shipments are in at least 20-ton lots. The timer settings may be changed to suit the material to be handled.

The solution pots are of 75-gal capacity and, at maximum feed rate, the concentration of sodium silicofluoride is approximately 0.4 per cent. Agitation is by jet-operated vanes, with the flow controlled by a pressure regulating valve. At one station, the solution is picked up by an ejector and forced into a main having a maximum back-pressure of 10 psi. Entrainment of air is prevented by throttling the ejector water pressure. At the principal station, the solution is picked up by an all-bronze centrifugal pump (installed in duplicate) and forced into a line having a maximum back-pressure of 26 psi. Entrainment of air is prevented by bringing makeup water into the solution pot from the discharge of the solution pumps. The regulating valve on the line to the jets is set for approximately 14 gpm, and a needle valve on the pump discharge is adjusted to allow continuous makeup. The solution is

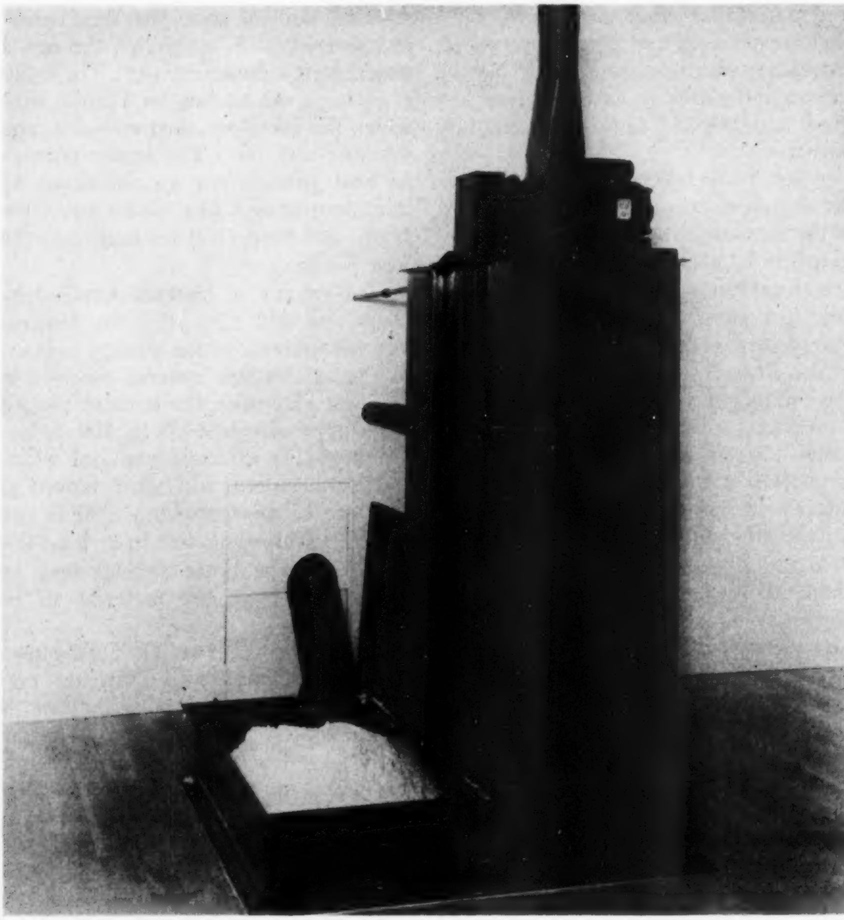

Fig. 2. Dust Collector

A dust collector is installed over each storage hopper, with the exhaust outside the building.

carried to the main in brass pipe and rubber hose.

A motor-operated valve located on the water line to each machine automatically closes when the machine shuts down. This prevents a heavy overdose in a slug of water at the station using the ejector and reduces the amount of waste water that would have to be disposed of at the station where the solution pumps are installed.

The machines are so wired that the plants will shut down when: [1] the feeder overfeeds; [2] the feeder underfeeds; [3] the water supply fails; [4] the screw conveyor fails to pick up material; [5] the screw conveyor overloads the feeder hopper; or [6] the

flows drop below 7 mgd (the low flow "cutout" setting used). If, for any reason, the principal plant shuts down, an alarm rings at a switchboard where an operator is always on duty.

Chemicals

The four chemicals that have been used to date in water fluoridation are hydrofluoric acid, fluosilicic acid, sodium fluoride, and sodium silicofluoride. The latter two are the ones most commonly used.

Hydrofluoric acid, produced in the reaction of sulfuric acid and fluorspar, is a primary product rather than a byproduct. Madison, Wis., seems to be the only city mentioned in the literature as using it. The commercial acid, normally 60 per cent pure, contains 57 per cent fluoride, is very corrosive, and is hazardous to handle. It has the advantage, however, of providing a very concentrated fluoride feed solution. Madison handles the acid under mineral oil and indirectly proportions it by pumping the oil (*2*).

Fluosilicic acid is a byproduct of the phosphate industry. In the reaction of sulfuric acid on the phosphate rock, which normally contains a low percentage of calcium fluoride, silicon tetrafluoride is evolved as a gas. When absorbed in water, the gas produces fluosilicic acid. The commercial product is 30 per cent pure, contains 23.7 per cent fluoride, and can be proportioned directly with the conventional diaphragm feeders.

Sodium fluoride is made by reacting sodium carbonate and hydrofluoric acid, both finished products. This chemical, used in all of the early plants, has the advantage of being the

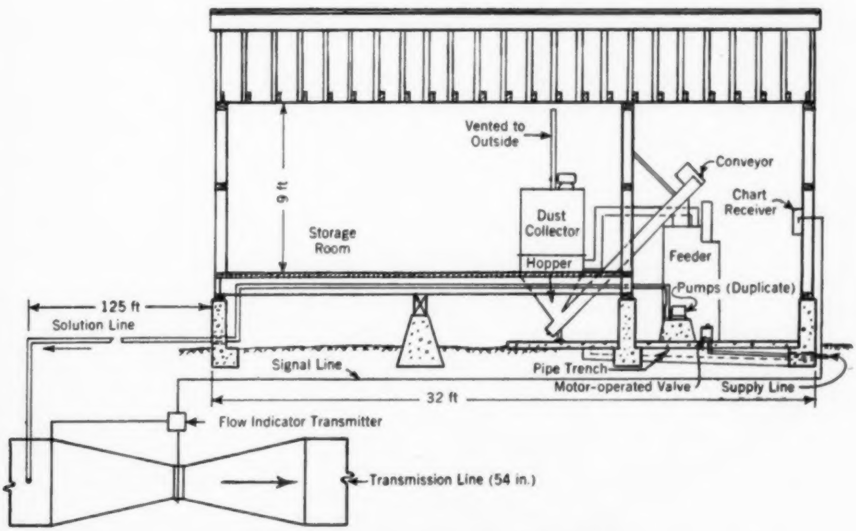

Fig. 3. Diagram of Fluoridation Installation

A sketch of the San Andres No. 2 fluoridation plant is shown. The equipment illustrated in Fig. 1 and 2 appears at the right.

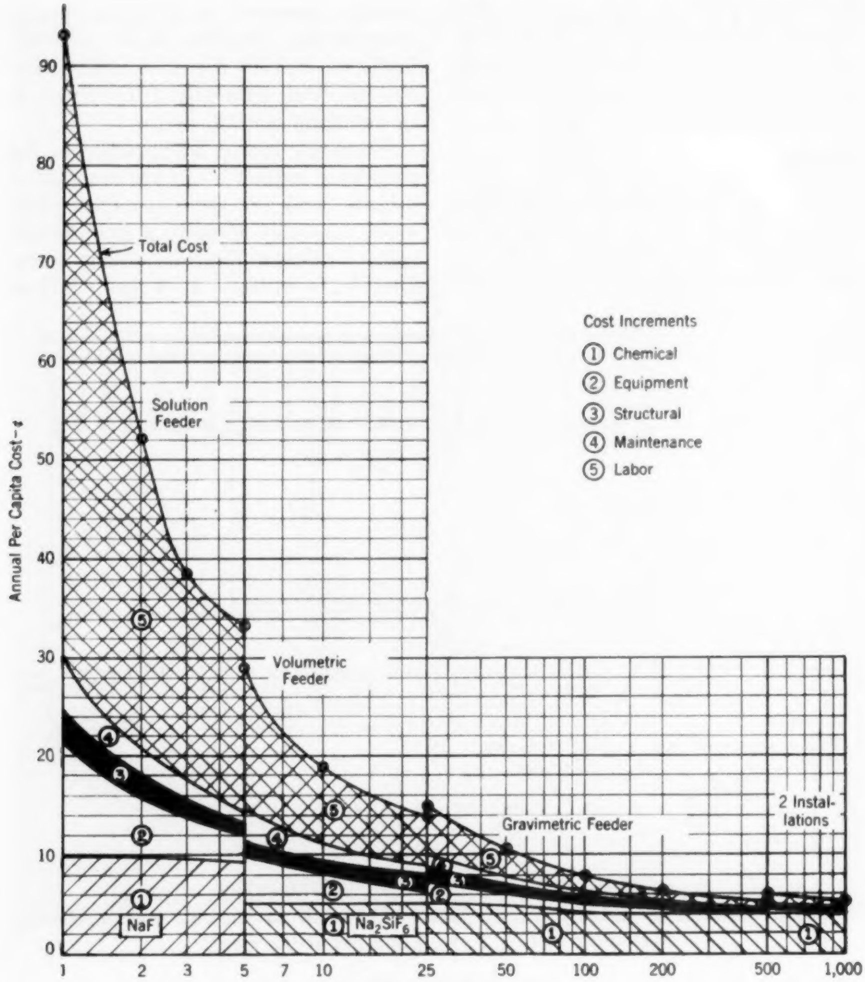

Fig. 4. Annual Per Capita Fluoridation Costs

The graph shows the increments for various categories of costs: 1—chemical (sodium fluoride for solution feeders, sodium silicofluoride for dry feeders); 2—equipment (1,000–5,000 population group, solution feeder; 5,000–25,000, volumetric feeder; 25,000–500,000, gravimetric feeder; 500,000–1,000,000, two gravimetric feeders; also includes cost of accessories and installation; amortization, 15 years at 5 per cent); 3—structural (plant structures and engineering; amortization, 30 years at 5 per cent); 4—maintenance (including miscellaneous operating expense); 5—labor (including laboratory control and supervision). The water consumption is assumed to be 100 gpcd and the fluoride dosage 1 ppm.

most soluble of the available commercial fluoride salts (4.0 per cent at 77°F), but it provides the smallest amount of fluoride per dollar. The commercial product is sold in two grades, 95 and 98 per cent, having an available fluoride content of 43 and 44.4 per cent, respectively. The chemical may be used in either dry or solution feeders. The dust hazard requires the use at least of respirators and gloves, dust collectors and additional protective clothing being desirable for large installations.

Sodium silicofluoride, the most advantageous chemical for all but small installations, is also a byproduct of the phosphate industry. Silicon tetrafluoride may be absorbed directly in sodium hydroxide, or fluosilicic acid may be reacted with the alkali. The commercial material is obtainable in two grades, regular (72 lb per cubic foot) or fluffy (55 lb per cubic foot), both containing 60 per cent available fluoride. The chemical may be purchased in 100-lb paper sacks—the most economical choice—or in fiber drums or wooden barrels containing 350–425 lb. Variations are found in the fineness of the material offered by different manufacturers. Table 1 shows the sieve analyses of commercial sodium silicofluoride samples from three domestic and one foreign source. Sodium silicofluoride presents the same hazards in handling as sodium fluoride, and the same precautions are necessary.

There has been talk of a shortage of fluoride chemicals, but suppliers of sodium silicofluoride assert that sufficient quantities are available for water works needs. Furthermore, in 1952 the imported material could be purchased in the San Francisco area at an appreciably lower price than the domestic, although none of the former has actually been bought by the city. There was, however, a reported shortage of fluosilicic acid late in 1952, owing to a lack of rubber-lined drums.

TABLE 1

Sieve Analyses of Commercial Grades of Sodium Silicofluoride

Type	Quantity Retained—*per cent*			
	40–100 Mesh*	100–200 Mesh*	200–325 Mesh*	325 Mesh†
A (domestic)	0.9	79.4	13.4	6.3
B (domestic)	3.5	49.4	29.2	17.9
C (domestic)	4.0	39.1	18.2	38.7
D (foreign)	6.0	57.6	19.4	17.0

* Passed 40 mesh, retained on 100 mesh, etc.
† Passed 325 mesh.

Costs

In the early information released on fluoridation, costs were presented in terms of the annual expense per capita. This basis was no doubt desirable for general public use but gave no inkling of the many variables that might place the costs outside the generally accepted range. In Fig. 4, annual per capita costs have been divided into five categories: chemical; equipment, accesso-

ries, and installation; plant structure and engineering; maintenance and miscellaneous operating expense; and labor, laboratory control, and supervision. It should be pointed out that the cost estimates, in most instances, were reasonably generous but actual costs may be greatly influenced by local conditions.

The chemicals were sodium fluoride for the solution feeders and sodium silicofluoride for the dry feeders. The following prices, quoted fob San Francisco, were used: sodium fluoride—$13.80 and $13.50 per 100 lb for less-than-ton and ton-to-carload lots, respectively; sodium silicofluoride—$10.85, $10.15, and $8.25 per 100 lb for less-than-ton, ton-to-carload, and carload lots, respectively. The amounts used were calculated on the basis of 1 ppm of fluoride, with an assumed consumption of 100 gpcd.

The equipment, accessories, and installation estimate provides for an automatic installation with all necessary auxiliary equipment, although no venturi tube installations are included. Estimates for large installations are based on San Francisco costs. Equipment is amortized over 15 years at 5 per cent.

Although many cities would require no new structures, particularly if a treatment plant already existed, estimates for this item have nevertheless been included. If structures are built, engineering and inspection charges must be incorporated, although little or nothing has been for the small plants. Engineering and structural costs are amortized over 30 years at 5 per cent.

Maintenance and miscellaneous operating costs cover equipment maintenance, power, heat, and miscellaneous but include no special allowances for automotive transport.

Labor is undoubtedly one of the most controversial charges and very often is disregarded when the work is to be performed by existing personnel. Obviously, the charge becomes extreme for a daily visit to a small installation for fluoridation purposes only. Laboratory or field kit test control is assumed, and a 15 per cent charge has been added for supervision.

The graph is intended only as a guide to costs, to show how they are distributed and to indicate why they vary inversely with the population. Where more than one installation is required, the total population may be divided by the number of installations and the cost read opposite the quotient population. The labor costs will always be too high in such instances, however, and should therefore be reduced.

If the actual consumption varies from the assumed 100 gpcd, the chemical cost would generally be the only item requiring an appreciable change, and it would be in direct proportion to the change in consumption. If the required dosage is not 1 ppm the chemical cost again would change, in direct proportion to the difference in dosage.

A second installation assumed for the 500,000–1,000,000 population group increases the cost only a little—approximately 7 mills per capita per year for a city of 500,000.

The costs, of course, reflect experience at San Francisco, where two installations fluoridate an estimated flow of 42 mgd. The graph figure of 6.3 cents per capita allows $26,460 per year.* Subtracting the plant and equipment depreciation costs leaves $23,390, an amount slightly less than the original estimate but very close to actual costs.

* For a population consuming 42 mgd at the assumed rate of 100 gpcd.

Fluoridation Problems

The literature on existing fluoridation plants indicates that the chief difficulties are hazards in handling chemicals, corrosion or scaling of solution lines, prevention of overdosage, and complaints from consumers. The present discussion, however, will be limited to San Francisco's experiences.

Design and Operation

The city's fluoridation program required the construction of two automatically controlled plants which would feed sodium silicofluoride, operate with a minimum of supervision, and give maximum protection against overdosage, as the solution was to be introduced directly into transmission lines. The major protective features have already been described. The principal problem was the electrical interlocking of equipment to give the desired results.

Conflicting data on the required size of solution pots led to tests on the rate of solution of a commercial grade of sodium silicofluoride (Table 1, Type *A*). It was found that a 0.4 per cent solution could not be obtained with a 5-min detention period at a temperature of 55°F. The tests did show, however, that the material could easily be maintained in uniform suspension at this concentration with a 5-min detention period. When the chemical was added at 30-sec intervals to a container having a continuous flow with 5 min retention, the maximum variation in the fluoride concentration of intermittent samples, as indicated by conductivity measurements of the diluted samples, was less than 5 per cent.

A number of minor problems occurred during initial operation, most of them resulting from handling a much finer material than was expected. The material received prior to plant design had a Type *A* sieve analysis and was supposed to be a representative sample of the commercial product. The material received in the first shipment was similar to Type *C*, however. Both types comply with the normal specification requirement that 95 per cent shall pass a 100-mesh sieve, but Type *C* material will not pour through a 3-mesh sieve, arches in a hopper, and seems to pick up a little moisture easily, thus increasing the internal friction. A vibrator had to be installed immediately on the auxiliary storage hopper in order to move the material into the screw conveyor. A small vibrator was later installed on the screen in order to facilitate loading and to utilize the storage space above the screen in automatic operation. Some heat is required in the chemical storage rooms, particularly in damp weather, and some insulation may be needed on the exposed storage hopper below floor level, as there appears to be a little condensation during cold, damp weather, causing the material to stick to the hopper walls. Low feeds in two or three instances may have been due to the sticking of this material on the feed screw.

Leakage past the packing of one of the solution pumps began after one month of operation. Inspection showed pitting of the pump shaft, which, the manufacturer states, is made of No. 416 stainless steel. The pump shaft was cut and stubbed with a No. 303 stainless steel shaft. The second pump began leaking badly after 2 weeks of operation and was similarly repaired.

Little information was available on the disposal of sacks. Incineration seemed the most promising method, and a unit was constructed from a piece of 44-in. pipe, 4 ft 6 in. long, fitted with

a grate, an 8-ft stack, and split doors, and set on a concrete slab (Fig. 5). Owing to a delay in fabricating the unit, 160 sacks had accumulated, requiring approximately 2 hours of incinerator operation. Three days afterward the needles on the windward side of a pine tree approximately 60 ft away began turning brown. Later a second tree was similarly affected, and an oak tree approximately 20 ft away showed damage, although not nearly so severe. There was little wind during the burning period and the smoke drifted by or through these trees before dispersing appreciably. Apparently the fluoride chemical remaining in the sacks produced a hydrogen chloride concentration in the smoke sufficient to cause the damage to the trees. Local conditions prevent the incinerator from being moved without considerably increasing the work of disposal. Therefore, the immediate solution adopted was to remove the dust from the sacks more thoroughly and to use short burning periods under favorable wind conditions.

No special personnel problems have been encountered as yet, although it has been observed that workmen tend to be lax about wearing respirators and protective gloves.

Laboratory Control

A California Dept. of Health statement of policy on fluoridation control (*4*) includes this paragraph:

"*Daily control tests of residual fluoride run by the water purveyor.* In the larger water systems adequately equipped and staffed it is anticipated that these will be run in accordance with procedures outlined in *Standard Methods*."

Most laboratories using the *Standard Methods* (*5*) tests for fluoride believe them to be open to improvement: they are subject to the usual human error of visual color comparison and the error due to interfering substances: they require the reagents to be in contact with the samples and the standards for equal periods (1 hour) to obtain consistent results; and the reagents are good for only approximately 30 days, even when stored in a refrigerator. Some work has been done with the method of Megregian and Maier, using a spectrophotometer, but San Francisco's experience indicates it to be more time consuming than the *Standard Methods* procedures. Therefore, it has not been adopted, although more accurate results seem to be obtainable in the 1-ppm range. Results for concentrations below 0.1 ppm are of no value, however.

Fluoride tests are now being run on twenty samples per week, nine of which are from the distribution system. The principal problem is the basic difficulty facing most water departments today—how to find the time to do the work with the limited staff available.

Public Relations

More public relations problems, most of which might better be described as annoyances, occur than any other, particularly in a city such as San Francisco, where the program was very controversial (*3*). While the question was before the board of supervisors and during the election campaign, the water department received numerous letters, both pro and con. It was the telephone calls that were sometimes annoying, as some vigorous opponents not only wanted to be sure that their letters had been read but also wished to get oral agreement with their ideas or to continue the discussion to prove their point. The water department main-

tained a neutral position on fluoridation from the beginning, but an occasional individual seemed to hold the department responsible for it, particularly if he had voted against the proposition. Just prior to initial operations, a few persons telephoned to inquire: "Have you started to put that rat poison in the water yet?"—as difficult a question

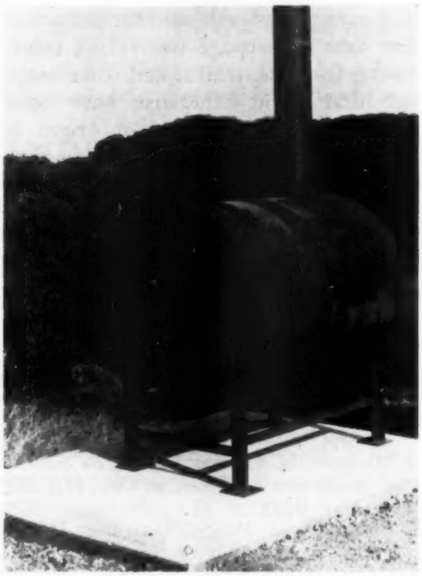

Fig. 5. Incinerator

This homemade incinerator was constructed from a 44-in. pipe.

to answer as "Have you stopped beating your wife?"

The fact that the program authorized by the board of supervisors provided for fluoridation in some districts but not in others invited criticism from both sides. A number of people favoring fluoridation who were not in a district that would receive it blamed the water department. Some, however, were very polite and said they were calling merely to state that they favored the program and hoped it would be expanded to include the entire city.

On the morning fluoridation began there was a flood of telephone calls, the majority from people living near the borderline of the areas receiving fluoridated water. A map showing the extent of the program had been published in a newspaper, with the suggestion that, if the map was not clear, consumers could call the water department for more definite information. Opinions voluntarily given favored fluoridation by a 3:1 majority. There were, however, a number of expressions of disapproval, some of which may be of interest. One woman complained that the "new stuff" made the water nauseating, warmer, sweet, and oily to the touch, although there was actually less than 0.2 ppm fluoride in it at the time. Another woman, whose home was outside San Francisco, called from work to complain of feeling listless and logy because of the fluoride in the water at her place of business. When informed that fluoridated water was not served to that address, she stated, after a moment of hesitation, that she got around the city during the day and drank water in other districts. She was not interested in the information that many people had been drinking water with a natural fluoride content for years without harmful effects. A third woman claimed that she had suffered from fluorosis all her life and, when the doctors gave up her case, began studying the problem and was curing herself. Of course, she continued, no books on the subject were available any more as the doctors had hidden them all. She added that what most people thought was aluminum poisoning was actually fluorine poisoning.

The principal conclusion which might be reached from these complaints is that, in general, relatively few of the opponents of the program who called did so to have their fears allayed. The majority wanted to express their grievances and a few were interested in learning the weak points of their story in order to improve their arguments for the next discussion.

Fluoride as Tracer

Fluoridation has provided unexpected aid in determining the source of seepage waters. Fluoride will not be removed while passing through the ground, and ground waters in the San Francisco area contain little if any of the element. Sewage will, of course, have approximately the same concentration as the water supply, but the most difficult problem is usually to determine whether the source of seepage is ground water or leakage from mains.

Considerable seepage in a new highway cut was believed by the road engineers to be coming from one of the reservoirs. Tests definitely proved that the seepage water had not originated in either the reservoir or the neighboring distribution system since the advent of the fluoridation program, which was a little over a month old. In another instance, seepage water was known to originate in the system, but the question was whether it came from an 80-year-old standby reservoir with water of less than 0.1 ppm fluoride content or from one of two pipelines nearby, carrying water with approximately 1 ppm and 0.5 ppm fluoride, respectively. As the seepage water contained approximately 0.5 ppm of fluoride, the source was soon located. The test has also been of value in several other instances of seepage.

A man with a leak detector can waste less time on seepage waters not originating from the mains, and some seepage that might otherwise have been classed as of undetermined origin is now able to receive more immediate attention. Thus, money is saved and public relations are improved.

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Plastic Service Pipe

Panel Discussion

A panel discussion presented on May 14, 1953, at the Annual Conference, Grand Rapids, Mich.

Pipe Characteristics—*Max K. Socha*

A paper presented by Max K. Socha, Engr. of Water Distr., Los Angeles Dept. of Water and Power, Los Angeles.

NOTHING has so profoundly aroused the interest of water works operators recently as the development of plastic pipe for water service. Plastics, although not new, received a tremendous impetus during World War II as an enforced substitute for metals and rubber. Industrial chemical advances made possible innumerable substitutions for critical materials. Many of these became permanent, while others were discarded as the more familiar materials again became available. It is apparent that plastic, in order to displace other materials permanently, must have and retain properties superior to the substances it supplants.

Since 1950 plastic materials have entered into the pipe field and have grown from infancy into a large and important industry. As with all new products the basic characteristics of which are not familiar to the average user, a degree of confusion exists. Many potential users are being urged to adopt plastic pipe without trial installations and with their minds filled with doubts and uncertainties. The purpose of this paper is to review the general use of plastic materials for water works service from the viewpoint of a typical operator. The somewhat limited information presented has been gathered since 1951.

Plastic pipe is resistant to rust, corrosion, chemical attack, and electrolytic action, and it has good hydraulic characteristics. The problem is to find plastic materials that will best satisfy the needs of water utilities from the standpoint of price, adaptability, suitability, dependability, durability, taste and odor qualities, and toxicity. These points will be taken up separately in this discussion.

The most extensive use of plastic pipe has been in the industrial field. Its resistance to corrosion, even in contact with strong acids, alkaline solutions, and other chemicals, eliminates the need for frequent replacement as compared with metal pipe, and the longer service life gives plastic pipe a tremendous economic advantage. In this field, the quantities required for a particular installation are relatively small and the value of the product high, so that price is not an important factor.

The situation in the water works industry is different, however. Water is, and always should be, an inexpensive product. To keep it so, installations for the delivery of water to the

consumer must be inexpensive, and plastics, if they are to enter successfully into water works systems, must compete favorably in price with the most successful materials now in general use. An increase in basic costs, however slight, must be offset by superior characteristics or adaptability.

General Criteria

At Los Angeles, as in many other sizable water systems, materials are not bought for a particular installation unless it is a large, special project. Purchases are stockpiled to meet anticipated needs for a given period. Service connections annually require approximately 500,000 ft of pipe or tubing, 80 per cent of which is of the 1-in. size. These installations are scattered over 500 sq miles of territory, along 5,300 miles of main at elevations from sea level to 2,700 ft. Although more than 80 service zones divide the system, rugged topography requires pressure ranges in the system from 40 psi to more than 250 psi in extreme instances. Service connection installations, which have been averaging in excess of 20,000 a year for more than 7 years, with peaks higher than 2,200 a month, require nearly 40,000 stopcocks and couplings annually, together with other fittings and connectors. As neither time nor facilities permit the selection of materials to suit the individual installation, pipe and fittings of wide adaptability must be utilized. Moreover, it is impractical to set up separate inventories for special conditions.

The field installation trucks are equipped and stocked with materials to meet a high installation rate and cannot carry special materials and tools for a variety of installations. Furthermore, the crews are trained in established procedures designed for high speed and efficiency. To be successful, a plastic pipe introduced into a large water system for general use must function satisfactorily under the different conditions encountered. It must fit in with the current installation practices of the utility or require only a low-cost modification, without too many special tools or extensive retraining of personnel. The introduction of plastic pipe must not cause the obsolescence of large inventories of fittings and stopcocks and must limit the necessity for carrying large numbers of special stock items in the warehouse.

The taste and odor of the water carried in plastic pipe, as well as the toxicity of the basic plastic material or plasticizers, should be carefully investigated by tests before the pipe is adopted for general water works purposes. In some plastics, there is a slow loss of plasticizer to the water carried. This condition may not be noticeable in flow tests, however slow the velocity, but may become apparent only when water is left standing in the pipe for a week or more. Such a situation may frequently occur when tenants are on vacation or property is unoccupied. The initial use of water for drinking after prolonged exposure to such plastics would assuredly result in numerous consumer complaints.

The question of durability of plastic pipe is one that cannot be answered readily. It is known that some plastics change their characteristics slowly, through aging; they become brittle or lose structural strength to an extent which has not been completely determined. It may be necessary to take some calculated risks in this regard, in the same manner as when other materials are pioneered.

One of the greatest causes of confusion concerning plastic pipe is the use of trade names to designate the products. Nearly all leading producers and extruders offer several kinds of plastic pipe, each made of a distinct basic material. These may differ from one another as much as do steel and concrete pipe. In the descriptions that follow, the use of trade names will be carefully avoided. Instead, the basic products utilized by numerous extruders of plastic pipe will be mentioned.

Cellulose Acetate Butyrate

Cellulose acetate butyrate,* extruded by a number of fabricators, has been used extensively for piping, particularly by gas utilities. Pipe made of this material is semiflexible and nearly transparent. It is sometimes pigmented to produce various distinctive colors for trade identification. The pipe is produced in the nominal copper tubing sizes and is handled and installed in a manner very similar to copper tubing.

The butyrates are easy to install and can be adapted for regular copper tubing tailpieces and other fittings. The pipe is flared or belled easily by dipping the ends in boiling water for approximately 1 min and then forcing the pipe over a simple forming tool preheated in boiling water. The pipe is rotated on the tool until properly shaped. Bends for meter box risers are made in the field or preshaped in the shop, using the hot-water softening method. Belled ends should have a slight taper to insure tight joints.

Joints are made by applying diacetone alcohol solvent to both the male and female ends of the pipe with a small paint brush and allowing approximately 30 sec for softening. The pipe ends are then forced together and set immediately. Opaque spots indicate poor joints.

The butyrate pipe tested was of the 1-in. copper tubing size with 0.10-in. wall thickness. Hydrostatic bursting pressure on jointed pipe was 750 psi for new pipe, failure occurring by bulging, as the pipe did not actually burst. When used pipe, after being in actual service for 1 year under a working pressure of 160 psi, was taken up for retesting, it split full length after 700 psi had been applied for 45 sec. It is believed that this failure was caused by the gradual loss of the plasticizer, tending to make the pipe progressively more brittle. The types of butyrate pipe tested appeared to have a tendency to split along surface scratches caused by rocks, sand, or other abrasive material in the soil.

All of the butyrate formulas tested developed a lingering, unpleasant taste and odor in the water sufficient to cause its rejection for use in the Los Angeles system. Extruders are attempting to modify the formulas to eliminate this objectionable feature.

The butyrates become very soft and pliable at temperatures above 140°F, making them vulnerable to failure from hot-water backup caused by defective water heaters. If this pipe is used in a water system, care should be taken to select locations serving new construction equipped with modern, thermostatically controlled water heaters and pressure relief valves, instead of the old, manually controlled or instantaneous heaters, where hot-water backups are more likely to occur.

Installation costs for butyrate pipe should be lower than for copper tubing. The price per foot of the plastic pipe is

* A product of Tennessee Eastman Corp., Kingsport, Tenn.

slightly less, and the labor cost should be lower because of its ease of installation and ready adaptability to standard fittings and processes.

Polyethylene

Polyethylene has been rapidly adopted for many pipe installations. The flexible type is particularly suitable for poor soil conditions, where it may be impossible to run straight pipe and snakelike installations are necessary.

Tests made on flexible polyethylene pipe showed that a slow flow or distortion occurs under hydrostatic pressures of more than 100 psi and continues until the pipe bursts. Its pressure resistance is considered too low for general-purpose use in Los Angeles. There was also some evidence of a lingering, unpleasant taste and odor in the water. Flexible polyethylene pipe has been successfully employed in water systems with moderate static pressures but would be unsuitable for systems with a wide range of pressure unless installed only in the low-pressure zones.

Rigid polyethylene has a bursting strength of 600 psi, which is much higher than that of the flexible type. The pipe must be joined by means of cemented fittings supplied by the manufacturer. This material also produces a lingering, unpleasant taste and odor in standing water. The pipe is very brittle and does not bulge at failure but splits longitudinally. It breaks quite easily in shipping and handling and probably would not withstand earth shocks and exterior loads or blows commonly encountered in actual use.

Rigid Polyvinyl Chloride

Tests were made on three types of rigid polyvinyl chloride pipe, supplied by several different manufacturers under different trade names. Type 1, a very brittle, grayish-white material, has a hydrostatic bursting pressure of 1,050 psi, showing a long crack with no bulge. It breaks easily in shipping and handling and produces a strong, unpleasant taste in standing water. The pipe may be flared or belled with boiling water. It is considered too brittle for use in water systems.

Type 2, gray in color, is characterized by a very high impact strength. It must be threaded and joined with molded, threaded fittings and is treated in the same manner as iron pipe. The plastic pipe has a hydrostatic bursting pressure of 1,180 psi, with a slight bulge and a very short crack; no fitting leaks at this pressure. The pipe becomes very soft and pliable at 270°F and brittle at approximately 20°F. It produces a very slight chemical taste.

The price is extremely high, approximately double that of copper tubing for the straight pipe and approximately nine times the cost of wrought iron for the fittings.

Type 3 is also gray in color and has a high impact strength. It cannot be belled or flared with boiling water. A blowtorch may be used to bell, flare, or weld it, but it is believed that the degree of skill and care required renders this method impractical for field use. The manufacturer supplies flared and belled fittings, which are joined by means of a special cement obtained from the producer. The pipe softens at approximately 250°F and becomes extremely soft at 270°F. Tests were not made at temperatures below 70°F, but the manufacturer claims that the pipe retains good toughness to −20°F. The hydrostatic bursting pressure is 600 psi, with a long split and very little bulge. The material produces a taste similar to linseed oil; the taste remained the same over a period of a

month. Prices compare very favorably with copper tubing of the same size. The manufacturer is attempting to eliminate the taste problem.

Conclusion

Plastic pipe holds great potential for the water works field, but much must still be learned before it supplants the metallic materials entirely. Each of the basic plastic products has its strong and weak points. The butyrates so successfully used by the gas utilities, although relatively inexpensive and adaptable, must overcome the taste and odor problem and the softening effect of hot-water backup. The polyethylenes, suitable for low-pressure conditions, pose jointing problems and would have only limited, selective use in large, complex water systems carrying high pressures. The rigid vinyls, provided their cost is not too high, have perhaps the greatest possibilities for widespread adoption in water systems. Other plastics, not discussed in this paper or yet to be developed, may prove to be the product the water industry is awaiting. Each water works operator must judge for himself whether the products now offered are suitable for his particular needs.

Field Experience—*Martin E. Flentje*

A paper presented by Martin E. Flentje, Research Engr., American Water Works Service Co., Philadelphia.

Water companies associated with the American Water Works Service Co. have experimented with plastic pipe. Their findings are of sufficient scope to be of some value.

Serious consideration was first given to plastic pipe for water service in 1950, when it became apparent there would be a shortage of copper. Long-range aspects also favored the acquisition of actual experience to determine the economic value of plastic material. As the cost of plastic pipe was comparable to or lower than that of copper and as it was in plentiful supply, a limited program of installing $\frac{3}{4}$- and 1-in. plastic services was instituted at fifteen selected companies in 1951.

Before the program was started, the author's firm investigated several kinds of plastic pipe, and one manufacturer's plant was visited. The pipe finally chosen was a flexible polyethlyene type recommended for potable-water and food-processing use. This type appeared best suited for field installation and accounts currently for approximately 75 per cent of all plastic pipe produced.

All plastic services are installed at locations where the pressure is less than 100 psi and in unpaved streets if possible. The pipe has also been used in conjunction with corporation and curb stops designed for copper tubing. Such connections were first made with molded plastic adapters. After periods ranging from a few days to several weeks following the initial installations, three types of failure were noted:

1. Fracture of the molded plastic adapters, due either to normal ground settlement or to concussion from a car or truck passing over the recently filled service trench.

2. Occasional small pinholes, apparently caused by defects in manufacture.

3. Longitudinal splits in the pipe wall at the adapters, presumably occur-

ring because the pipe had been stretched slightly when the adapter was inserted. The split may have been due to pipe wall stresses caused by such enlargement and also to compression under the clamp used to join the pipe and adapter.

To correct these difficulties, brass adapters were obtained to replace those of molded plastic, and the manufacturer decided to produce a heavier-wall pipe for water services. The new wall thickness is 0.173 in. and 0.181 in. for the ¾- and 1-in. sizes, respectively—an increase of approximately 50 per cent.

These changes appeared to remedy the trouble previously encountered, and the scope of the experiment was extended to all 111 of the operating companies. A tabulation early in 1953 showed that 850 plastic service installations had been made; the present figure probably exceeds 1,200. There have been relatively few failures reported, indicating that the bulk of the prior difficulties have been overcome.

One problem has been to procure clamps made entirely of stainless steel. Some of those furnished had only a stainless steel band, with the worm and clamp body of a different composition which corroded very quickly. An all-plastic clamp that has since been developed and is now being tested may prove to be a satisfactory substitute but no definite conclusion has yet been reached on this item.

There have been no reports of toxicity or taste and odor due to plastic pipe.

Many minor difficulties have been encountered, mainly owing to the fact that the manufacturer was unacquainted with public water supply practices and requirements. The plastic industry appears to recognize the necessity for standardization if its products are to be accepted for use in water works installations.

Satisfactory water service installations may be made with plastic pipe currently being produced, and there are strong indications that new types will also be favorable for such use. Only time, continued research, and future developments will tell whether plastic pipe for water service will prove to be as successful as copper tubing.

Testing Program—*Walter D. Tiedeman*

A paper presented by Walter D. Tiedeman, Exec. Director, National Sanitation Foundation Testing Lab., Inc., Ann Arbor, Mich.

The National Sanitation Foundation has undertaken some extensive tests of thermoplastic pipe under the sponsorship of the Society of the Plastics Industry, Inc. Guiding the work is a committee consisting of a representative of AWWA, a state health officer, three state sanitary engineers, and five technical representatives of manufacturers engaged in preparing the basic materials and extruding plastic pipe.

Tests are to be made on 28 different samples of plastic pipe, classified as cellulose acetate butyrate, polyethylene, polyvinyl chloride (including Saran *), and styrene rubber copolymers. These studies are designed to determine whether any aggressive natural water will extract deleterious or possibly toxic material from any of the samples

* A product of Dow Chemical Co., Midland, Mich.

of plastic pipe. Many different waters have been used, generally from public supplies. It is interesting to note that none of the plastics under test are materially affected by weak acids, so that slightly acid waters do not attack the basic material. Plastic pipe has been used successfully to replace steel pipe in one location where the soil was acid enough, as the result of the discharge of chemical wastes, to decompose steel pipe within a year.

In addition to extraction tests, the long-range effects of air, water, and soil upon the various types of plastic pipe are being studied. An important phase of the work is the taste and odor testing of samples of aggressive water in contact with cut portions of plastic pipe for long periods, as well as the testing of similar water recirculated for considerable periods through systems of plastic pipe and fittings. A taste panel has been established to test samples regularly. As many water supplies have pronounced tastes and odors, it is necessary to determine whether there has been any change in character or intensity resulting from contact with the plastic. It is interesting to note that solvents and cements used in jointing compounds appear to be of greater importance than the plastic pipe itself in affecting the taste and odor of water.

Colonies of rats are being fed on aggressive water that has been in prolonged contact with plastic pipe. It is too early to report on this phase of the work, however. It may be mentioned here that the steering committee has decided that none of the technical data will be released until the project is completed and a report approved for publication.

Studies are also being conducted on the effects of plastic pipe on the many forms of microbial life in water, as well as on the possible effects of such organisms on the plastic. Furthermore, it is to be determined whether the recommended procedure for disinfecting newly constructed water lines is applicable to plastic pipe.

The tremendous variety of products that could be marketed as plastic pipe is impressive. In addition to different basic resins and combinations of such resins, variations may result from changing the plasticizer, antioxidant, mold lubricant, filler, or coloring material. Consequently, one of the ultimate aims should be to recommend a method whereby the man in the field may identify the varieties of plastic pipe tested and found satisfactory.

It is hoped that the tests will provide water works or control officials with the necessary information on the possible effects of plastic pipe upon the potability of public water supplies. Other tests will be made, or the cooperation of other testing agencies will be sought, in an effort to publish under one cover all information on plastic pipe, including that related to its strength and physical properties, which such officials are likely to require in the performance of their duties.

Oil Field Techniques for Water Well Drilling

By Harvey A. Mylander

A paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by Harvey A. Mylander, Dist. Engr., Water Supply Analysts, South Pasadena, Calif.

IT is the purpose of this paper to summarize briefly some of the most useful oil field techniques that are fully developed and readily adaptable for water well drilling. Some of the steps in the construction of a hypothetical water well by the rotary method will be described, outlining the proper use of various techniques available.

At present relatively large deep wells are being constructed by rotary drilling. Essentially, this method utilizes a bit on a slowly revolving stem (drill pipe) that is lowered from a mast or derrick at a rate to match the cutting rate at the bit. Drilling fluid is circulated downward through the drill pipe, cooling the bit and floating the cuttings to the surface through the well bore. In unconsolidated formations, the drilling fluid is thickened and its specific gravity increased by adding "drilling mud," which consists of a wide variety of clays and fine minerals. Usually a pilot hole is drilled first and then reamed to final diameter in one or more passes. After the well bore has been completed, the casing is lowered into place, the space between the bore and the casing generally, but not always, being packed with gravel. Preslotted casings and well screens may be installed, or solid casings may be sunk and later perforated by numerous devices.

No attempt will be made to compare wells drilled by the cable tool or percussion method with those constructed by the rotary method. Most of the techniques, tools, and instruments described in this paper, however, find application in rotary-drilled wells only. As this discussion progresses, it will become obvious that, if certain techniques and geological conditions are overlooked while drilling, the result may be a structure the defects of which are difficult to diagnose or remedy once the casing is in place and the gravel pack completed. A good rotary-drilled water well must be constructed straight and of the same diameter throughout; the casing must be well centered; the proper size of gravel must be used for the pack; and the well must, of course, penetrate productive aquifers. The oil industry can furnish tools to enable each of these conditions to be met.

Directional Surveys

Initial interest in the surveying of boreholes began long before the turn of the century, in connection with deep, exploratory drilling operations in South Africa. It became increasingly evident that holes started straight at the surface did not remain vertical as the bit penetrated steeply dipping beds of different hardnesses. The surveying instruments used may be classed as single shot or multiple shot. The single-shot type may record the results photographically or mechanically, while the multiple-shot type is usually confined to photographic

recording on film strips. Single-shot instruments are arranged to be dropped inside the drill pipe or lowered on one-strand piano wire. Multiple-shot instruments operate with self-contained batteries and clockwork, or they can be energized from the surface through an electric cable.

Well-surveying instruments may indicate either drift alone or drift and direction. Drift indicators ascertain the angle of inclination from the vertical (drift) of the well bore but do not give the direction of this inclination. These instruments provide a permanent record for each run. The drift indicator probably is the most extensively used well-surveying instrument available today. Many drilling contracts specify that the angle of the well shall at no point exceed 1-deg or 3-deg drift. This limitation helps to assure the well owner that no sharp kinks or "dog legs" will impede the running of casing and that mechanical difficulties will not be encountered. In a water well, it is seldom necessary to require more than a drift survey.

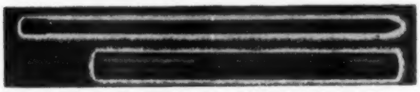

Fig. 1. Drift Indicator

The lower portion of the illustration is an exterior view of a single-shot, photographic drift indicator. The barrel, shown above it, is made of nonmagnetic metal.

A single-shot drift indicator of the photographic type is illustrated in Fig. 1. A battery-operated lamp is focused through a freely suspended plumb bob, projecting a dot on calibrated photographic paper. A watch at the surface and one in the capsule are started simultaneously. After the prescribed cycle has been completed, the capsule is withdrawn and the film disk is removed and developed in the field. In the mechanical type, a sharply pointed plumb bob hits a calibrated disk of soft paper, making a punch mark.

Single-shot instruments are usually used by the driller to make sure that the well is within the specified limits of declination as the drilling progresses. Multiple-shot instruments are used by the owner or the engineer to survey the entire well as a part of the acceptance tests.

An interesting example of the use to which such a survey may be put is found at Houston, Tex. During the operation of a certain well, the gravel pack settled below the screen, allowing excessive sand to be produced. As the upper section had been cemented to seal out surface contamination, additional gravel could not be introduced through the well bore. Employing careful directional surveys, a gravel chute was drilled to intersect the well just above the screen. Gravel was pumped in and the sand successfully stopped. The original production of 1,500 gpm has been raised to 2,000 gpm without the appearance of excessive sand.

Electric Logging

Electric logging, when used to its fullest capabilities, especially in the pilot hole, can reveal a great deal of information of interest to the water well driller. As sand boundaries can be accurately located, potential aquifers can be distinguished from formations with no probable yield. The depth and thickness of the potential aquifers can be determined accurately, precluding the necessity of setting expensive perforated pipe opposite nonproductive strata or brackish aquifers. Because electric logs of wells whose bore holes penetrate the same formations are correlative over surprisingly great distances, an

estimate of comparative drawdown is possible. The resistivity (electrical resistance of a cubic volume) of formation water can be determined and an equivalent sodium chloride salinity inferred, thus providing a qualitative evaluation of the formation waters that will be produced. The porosity of the aquifer, and, hence, its total volume of water, can be calculated from water resistivity and formation resistivity determinations.

An electric log of a well consists of a continuous and simultaneous recording of the spontaneous potentials encountered in the bore hole and the resistivities of the formations penetrated by the bore hole. Ordinarily, more than one resistivity curve is recorded, and the curves are a result of the spacings of the electrode configuration used in the particular measurement.

The electric log is obtained by lowering a system of electrodes into the uncased bore hole and recording the spontaneous-potential and resistivity curves photographically at the surface. As the cable and all necessary instruments are brought to the well in a specially designed truck, the only preparation required of the drilling crew is that the hole be in good condition and filled with drilling fluid. A rig or gin-pole over the hole is necessary to support the logging equipment lowered into it.

A water well of ordinary depth (500–2,000 ft) can be logged in approximately one hour. The log is roughly interpreted for the client at the well site immediately upon completion of the run (*1*). The economy and speed with which the electric-log information can be obtained warrants its use in a large percentage of all wells drilled by rotary methods. Today considerably more than 90 per cent of all wells drilled for oil are electrically logged, and in recent years this technique has been applied to wells drilled for water with such good success that in the San Joaquin Valley approximately 50 per cent of all rotary drilled wells are electrically logged (*2*).

Field interpretations are made by the operator, who may not have full geological information on the area. Detailed interpretation and comparison with electric logs of neighboring wells should be made by a competent ground water geologist with a knowledge of the locality.

Radioactive Logging

In any well where the casing has been installed, electric logging is ineffective. Therefore, it is necessary to resort to more complicated methods, such as radioactive logging, which takes advantage of the fact that the various strata of the earth's crust maintain continuous radioactivity to a degree that depends on the type and constitution of the formation (*3*). There are two kinds of radioactivity logs: the gamma ray (natural radioactivity) and the neutron (artificial radioactivity) log. The former provides a curve that can be interpreted in somewhat the same manner as an electric log. Similar hoisting equipment is used.

The neutron log is a measure of the secondary emission obtained by subjecting the adjacent formation to a bombardment of neutrons. The magnitude of the secondary radiations is controlled by the amount of hydrogen present in the stratum and is directly related to the porosity and fluid content (*4*). A source of high radioactivity is passed through the formations ahead of the logging device. The required strength of this source and the design of the detector were determined by exhaustive research. Because the radiations must penetrate the well casing and be picked up by electronic devices, the results may

not be as accurate or as sensitive as electric logs in uncased holes. Although radioactive logs are not as easy to interpret as electric logs, excellent progress is being made with radioactive methods and there is certainly no better technique available for the cased well.

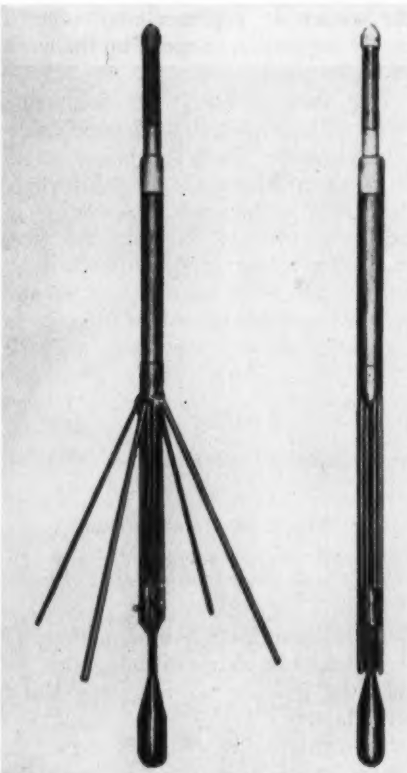

Fig. 2. Caliper Tool

The caliper tool is shown open (left) and closed (right). The hinged arms are spring loaded and follow the changes in the diameter of the hole.

Caliper Survey

It has been learned in recent years that rotary-drilled holes do not generally represent a cylinder the diameter of which would be the size of the drill bit. There are many causes of such deviations, the most important probably being chemical and hydraulic action on the unconsolidated formation. Shallow fresh-water sands and gravels will usually continue to heave, slough off, and circulate out of the hole after the bit has passed a given point. This irregular enlargement can be an expensive source of trouble if the extent and depth of the enlarged sections are not taken into account during the later stages of construction.

The modern caliper tool is a chrome-plated device, 3 in. in diameter and 6 ft long, with four arms hinged to it (Fig. 2). A shielded electric cable is used to lower the tool to the well bottom, where the arms are released and press against the wall of the bore hole. As the caliper is slowly withdrawn from the well, the spring-loaded arms follow every change in the diameter of the hole. These changes are transmitted over the suspending cable and recorded at the surface on photographic film. Hole diameters varying from 3 to 33 in. are automatically and continuously plotted in this manner (*5*).

Two of the more common uses for the caliper survey are: [1] calculating the quantity of gravel necessary to gravel-pack the hole behind the casing properly and [2] choosing sections suitable for locating centering devices for the casing within the well bore.

Magnetic Detection

An electromagnetic device * has been developed to locate the point at which pipe is stuck in a well, or the lowest point at which it is free and can be recovered. It is claimed that the sticking point can be located within 1 ft. When the device is used in drill pipe,

* The "Magna-Tector," a product of McCullough Tool Co., Los Angeles.

the sticking point can be found quickly, so that the pipe can be cut off, shot, or backed off at the lowest possible place before enough time has elapsed to allow more of the pipe to become stuck.

The instrument is lowered inside the drill pipe on an electrical cable, and the electromagnets at both ends of the device are energized, magnetic force holding it firmly against the pipe. When upward strain or stress is applied to the pipe at the surface, any movement

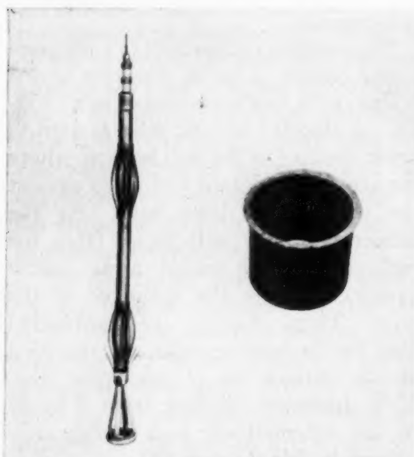

Fig. 3. Jet Casing Cutter

This device directs a jet of gases against the pipe wall, causing a plastic flow of the metal.

of the pipe between the two electromagnets is detected by a supersensitive electronic micrometer, midway between them. If the pipe stretches even a fraction of a thousandth of an inch, that information is instantly relayed to the surface. As movement at the testing point indicates free pipe, tests are made progressively downward until no movement is recorded, showing the pipe to be stuck. Then, by testing at small intervals, the upper boundary of the stuck portion can be determined.

Construction Aids

A number of devices may prove useful in overcoming difficulties during construction of the well. The driller will, of course, usually have his own methods of eliminating the trouble, but the owner or engineer may offer a timely suggestion to speed up the work or lessen inconvenience.

One such device is the jet casing cutter (Fig. 3), which is extremely simple to operate. It is run into the well on an electrical cable to the point where the cut is to be made. A charge of explosive material is then released, producing an extremely high-speed jet of gas. The gases are concentrated and directed against the wall of the pipe in such a manner that they cause a plastic

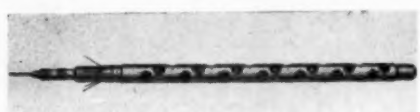

Fig. 4. Perforating Gun

The conventional perforating gun depicted can be loaded with shaped charges.

flow of the metal. A small amount of the metal completely disintegrates, so that the pipe is severed in a clean, straight line.

A slight flaring (Fig. 3) occurs at the point of severance, owing to the pressure exerted by the jet. This flare can be used as a natural adapter. The aluminum case of the cutter head is expendable, but all steel parts of the assembly, such as the sinker bar, rope socket, and cutter body, are pulled out of the well with the cable.

To destroy or fragmentize material such as lost tools or large boulders at the bottom of a well, the bottom hole jet cutter is a most useful device. This jet tool, fired from the electronic control panel of a service truck, focuses

detonating gases to a beam. The cutter consists of an aluminum alloy case, firing head, and shock absorber. The body of the tool contains a charge of high-explosive material, so arranged and shaped that it creates a high-velocity jet when detonated. The gases are directed downward and controlled in such a manner that, when the tool is positioned directly over an object in a well, the jet will cut the object into pieces. These may be drilled, recovered, or pushed into the wall of the well bore. The aluminum parts of the tool disintegrate in the well, but the steel parts (sinker bar, centralizer, and firing head) are pulled out by the cable from which the tool is run.

One shot is often sufficient to allow drilling operations to proceed, but, if the object to be eliminated is large, several shots are sometimes required. The tool can also be used to advantage for breaking through extremely hard shells or cracking a formation.

Fig. 5. Effect of Glass Jet Perforation

This photograph illustrates the effect of four shots, using glass jet perforators, on a solid cement structure. The shots first passed through a casing cemented inside a drill pipe.

Temperature, Pressure, and Flow Surveys

Instruments for obtaining temperature, pressure, and flow data within a

well have been developed (*6*). Readings taken as the devices pass through the region of interest are transmitted to the surface and recorded on a strip chart in graphic form, correlated with the depth at which the measurements are made.

The temperature and pressure data furnished by these variable-frequency electronic instruments are highly accurate. Pressures can be determined to one part in 5,000 and temperature to 0.05°F. Relative flow indications are obtained through the use of a collapsible packer assembly and flowmeter.

Fig. 6. Glass Jet Shaped Charge

When fired, the unit disintegrates into colloidal particles finer than sand.

Temperature and flowmeter devices have been used to determine the location and amount of hot water entering a water well. Temperature surveys can also be employed to identify various strata. In Illinois and other states where intensive studies of ground water basins have been made, it has been found that the different strata have characteristic temperatures.

Projectiles and Shaped Charges

For many years oil wells have been almost universally perforated with projectiles accelerated through a short barrel by a concentrated explosive. Recently the same or better results have been obtained by using shaped charges, eliminating the solid-steel gun body, the precision barrels, the fluid-tight receptacles for the explosives, and the accurately machined, heat-treated projectiles.

Some water wells may be economically perforated by projectiles or shaped charges. Certainly the rehabilitation of any oil well for water production should be undertaken with the full knowledge that ordinary water well perforating tools are not sturdy enough to penetrate the heavy oil well casings. These casings are usually sealed with pumped cement to insure thorough water shutoff. Hence, the sections that were originally the most securely sealed are the ones under study for water production.

Fig. 7. Pneumatic Seal

In use, the seal is welded to a section of pump column. The vulcanized-rubber portion can be inflated or deflated from the surface.

George L. Smith (*7*) reported the use of shaped charges to reopen the passages in a sandstone formation. The tool described was a conventional per-

forating gun similar to that shown in Fig. 4. The resulting increase in specific yield was attributed by Smith to the removal of deposits in crevices and other water passages.

Shaped charges also have the ability to fracture an adjacent formation and actually bore small drain holes in it. Figure 5 illustrates the effect of four shots, using glass jet perforators (Fig. 6), on a solid cement structure after passing through a $4\frac{1}{2}$-in. casing cemented inside of a $5\frac{9}{16}$-in. drill pipe. The fractures in the cement are obvious, and it is safe to assume a more pronounced effect in limestone and sandstone water-bearing formations, as these must already be fractured to allow the transmission of water.

The glass jets may be mounted in a regular steel carrier or in a steel strip carrier. When fired, the jet units disintegrate into colloidal particles finer than sand. The strip carrier is retrieved from the well on the shooting line.

Vibratory Explosives

Another method of using controlled explosives to improve the yield of wells is to vibrate the casing to remove incrustation and other impediments from it and from the interstices of the surrounding formation. A previous article has described the method and the excellent results obtained (*8*). Although vibratory explosives were designed expressly for water well development, they have recently found application in oil wells also. In this instance, the water industry offers an advanced technique to the oil men.

Pneumatic Well Seals

In the oil business, there are packings of every possible description to meet every conceivable condition, but most of them are unsuitable for use in large-diameter water wells. One device which can be employed in water wells, however, is a pneumatic seal that forms an integral part of the pump column pipe. It is simply a barrel-shaped structure welded to a section of the pump column, with the center portion replaced by a vulcanized-rubber girdle that can be inflated or deflated from the surface through a $\frac{1}{4}$-in. steel pipe (Fig. 7).* The seal is installed deflated and thereafter kept inflated during the period of use. Upon removal, it can be deflated for easy handling.

TABLE 1

Average Costs for Typical 500-ft Water Well

Straightness Surveys		
Single shot		
Drift only		$ 65
Drift and direction		100
Multiple shot		
Drift only		100
Drift and direction		150
Perforating		
No. of Shots	Gun	Shaped Charge
10 (min.)	$ 250	$ 300
20	300	350
40	375	450
60	450	565
100	600	800
500	1,950	2,700
over 500, *each*	3	4.50
Other Items		
Electric logging		$300– 400
Radioactive logging		300– 400
Caliper surveys		300– 400
Magnetic detector		150– 175
Jet casing cutter		200– 270
Bottom hole jet cutter		300– 400
Temperature, pressure, and flow surveys		300– 400
Vibratory explosives		250–1,000
Pneumatic seal		300– 600

* A product of General Pump Service, Inc., Los Angeles (patents pending).

A typical example of the use of the pneumatic seal is offered by an Azusa, Calif., well owned by the Southern California Water Co. The well was completed in 1944 to a depth of 446 ft, with a 16-in. casing. Eight separate producing zones were perforated in the usual manner. In 1951 the well began producing sand in such quantities that it was considered impossible to use it another season. A study showed that the upper five zones, down to 187 ft, were all producing sand, while the rest were clear. It was concluded that the upper zones must be sealed. A pneumatic seal was installed for $500 (compared with bids of $1,500 for liners and $750 for cementing), and the desired results were obtained.

Conclusion

This article has outlined several interesting techniques, methods, and specialized tools to assist in constructing a good rotary-drilled water well. All are seldom required in a single well, but the owner or engineer can select those applicable to the conditions involved. Average costs are shown in Table 1.

The services described are all available near producing or exploratory oil well installations. Oil field service firms are generally receptive to water well problems and seem eager to broaden the base of their operations. Hence, a communication to company headquarters will bring an amazing display of elaborate equipment and talent with surprising speed. Because the service crews operate 400–500 miles from their home base, very few sections of the United States using water wells extensively are beyond the reach of such service. The final determining factor is the matter of economy, which can be evaluated only by the owner or engineer.

Acknowledgment

Special thanks are extended to R. M. Ebaugh, Construction, Maintenance, and Production Supt., Southern California Water Co., Los Angeles, for suggesting the subject and sources of material; to T. M. Carroll, Mgr., Water Well Drillers Assn. of Southern California, Temple City, Calif., who reviewed the manuscript; and to the numerous firms that made available charts, photographs, field examples, and descriptions of equipment and methods.

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AWWA C400-53T

American Water Works Association

Tentative Standard Specifications *for* Asbestos-Cement Water Pipe

These "Specifications for Asbestos-Cement Water Pipe" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of their use for any installation must be subjected to review by the engineer responsible.

Approved as "Tentative" May 15, 1953

- **Price of reprint—20¢ per copy**
- **Approximate date available—July 31, 1953**

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

Tentative Standard Specifications for

Asbestos-Cement Water Pipe

Foreword

These specifications cover asbestos-cement pipe, laid underground in public highways or private rights of way, to be used to distribute municipal water supplies. They cover the minimum requirements for the conditions under which the material is presumed to be used.

The use of the terms "Class 100," "Class 150," and "Class 200" applied to asbestos-cement pipe produced under this document is not intended to imply that the material, when initially installed, is the engineering equivalent of cast-iron pipe bearing the same designation.

With these factors of limitation understood, the Committee on Water Works Practice accepts these specifications as prepared by its Working Committee (S. M. Clarke, chairman) and transmits them for publication to the Board of Directors of AWWA and the Executive Committee of NEWWA.

As the document must remain tentative for at least one year, the Working Committee is continued.

L. R. Howson, *Chairman*
AWWA Committee on Water Works Practice

Sec. 1—Scope

These specifications cover asbestos-cement pipe installed underground, intended for the conveyance of water, in sizes up to and including 36 in. in diameter, and for maximum working pressures of 100, 150, and 200 psi.

Note: In general, it is recommended that, for underground water distribution systems, Class 150 pipe be the lightest used. Local installation and operating conditions may establish other criteria than normal operating pressure for the pipe wall strength. Trench loads, surface loads, excessive water hammer, and corrosive soils are other factors that should be considered.

Sec. 2—Supplementary Details to Be Provided by Purchaser

When pipe is purchased under these specifications, it will be necessary for the purchaser to make supplementary specific statements, for each size and class of pipe, regarding:

(a) Nominal inside diameter.

(b) Class of pipe.

(c) Total laying length of pipe.

(d) Total number, lengths, and extent of machining of short sections for making connections to valves, fittings, or structures, and for making closures.

(e) Specifications for acceptable couplings, if couplings other than the standard ones of the pipe manufacturer are required.

(f) Whether factory inspection by the purchaser will be required.

(g) Whether three-edge bearing tests will be required.

Sec. 3—Definitions

Under these specifications, the following definitions will apply:

3.1. *Purchaser:* The person, firm, corporation, or governmental subdivision entering into a contract or agreement to purchase pipe according to these specifications.

3.2. *Manufacturer:* The person, firm, or corporation that manufactures the pipe.

3.3. *Inspector:* The representative of the purchaser, properly authorized and limited by the particular duties and responsibilities entrusted to him.

3.4. *Inspection:* Inspection of the pipe and of the tests, at the manufacturer's plant, by the inspector.

3.5. *Working pressure:* The maximum hydrostatic pressure to which the pipe will be subjected in normal operation after installation, exclusive of allowance for water hammer.

Sec. 4—Inspection

4.1. This section shall apply only when factory inspection is specified by the purchaser.

4.2. The manufacturer shall notify the purchaser in advance of the inspection and testing of the pipe, in order that the purchaser may be represented at such tests and inspections.

4.3. The inspector shall have free access to those parts of the manufacturer's plant which are concerned with the inspection and testing of the pipe in accordance with these specifications. The manufacturer shall afford the inspector, without charge, all reasonable facilities for determining whether the pipe meets the requirements of these specifications.

4.4. Should the purchaser have no inspector at the manufacturer's plant, the manufacturer shall, if required by the purchaser, furnish a sworn statement that the requirements of these specifications have been met.

4.5. The inspection shall not relieve the manufacturer of his responsibility to furnish and deliver pipe and couplings conforming in all respects to the requirements of these specifications.

Sec. 5—General Requirements

5.1. *Materials.* Pipe shall be composed of an intimate mixture of Portland cement or Portland puzzolana cement and asbestos fiber, with or without the addition of curing agents; shall be free from organic substances; and shall be formed under pressure and thoroughly cured.

5.2. *Classes of pipe.* Pipe shall be made in three classes, for maximum working pressures of 100, 150, and 200 psi, designated as Class 100, Class 150, and Class 200, respectively.

5.3. *Pipe diameters.* Pipe shall be made in nominal inside diameters of 4, 6, 8, 10, 12, 14, 16, 18, 20, 24, 30, and 36 in. For the 4-, 6-, 8-, 10-, and 12-in. sizes, the actual diameters may be less than the nominal by not more than 5.0 per cent, when measured approximately 3 in. from the ends of the pipe.

5.4. *Pipe lengths.* The standard length of pipe shall be not less than 13 ft. At least 90 per cent of the total footage of pipe of any one class and size, excluding short lengths, as specified below, shall be furnished in standard lengths, with a tolerance of ± 1 in. The remaining 10 per cent may be in random lengths of not less than 7 ft. All random lengths shall be cut only from standard lengths that have met the requirements of Sec. 8.3.

Short lengths for making connections to valves, fittings, and structures, and for making closures, shall be furnished in such numbers and lengths as specified by the purchaser.

Short lengths shall be not more than 3 ft 3 in. long for the 4-in. and 6-in. sizes, and not more than 6 ft 6 in. long for the 8-in. and larger sizes.

TABLE 1

Flexural Strength

Nom. Diam. *in.*	Total Applied Load—*lb*		
	Class 100	Class 150	Class 200
4	900	1,100	1,400
6	2,100	2,800	3,700
8	4,000	5,700	7,600

The coupling areas of all standard and random lengths shall be machined or otherwise rendered suitable for making a tight joint with the couplings. The short lengths shall be properly machined for their purpose, whether at ends only or over their entire length, as specified by the purchaser.

5.5. *Couplings.* One coupling of the size and class specified shall be furnished with each standard, random, and short length of pipe. Unless otherwise specified by the purchaser, each coupling shall comprise an asbestos-cement sleeve, of the same composition as the pipe, and two rubber rings.

Sec. 6—Detail Requirements

6.1. *Wall thickness.* The wall thickness at the machined portions of any pipe shall not deviate from the manufacturer's standard by more than +0.16 in. or −0.08 in. for pipe having a design thickness of 1 in. or less, nor by more than +0.20 in. or −0.10 in. for pipe having a design thickness greater than 1 in.

6.2. *Straightness.* No pipe shall have a variance from straightness, measured as an outside middle ordinate, of more than 0.625 in. for 13-ft lengths, or of more than a proportionate amount for shorter lengths.

6.3. *Imperfections.* Each pipe shall be free from bulges, dents, and tears on the inside surface that result in a variation in diameter of more than 0.187 in. from the diameter of adjacent, unaffected portions of the surface.

The coupling areas of the barrel of each pipe shall be free from dents and gouges that will affect the tightness of the joint.

The exterior surface or edge of machined ends shall be free from flaking that extends back more than $\frac{1}{2}$ in. from the end, that has a depth of more than $\frac{1}{8}$ in., or that extends around the perimeter more than $\frac{1}{2}$ in. at one location.

Sec. 7—Strength Requirements

7.1. *Bursting strength.* Each pipe and each coupling shall be designed to have sufficient strength to withstand an internal hydrostatic pressure of four times the rated working pressure for the class of pipe.

7.2. *Flexural strength.* Each standard length of pipe of 4-, 6-, and 8-in. nominal diameter shall, when tested in flexure as specified in Sec. 8.3, support the load indicated in Table 1.

7.3. *Crushing strength.* Each pipe shall have sufficient strength, if submitted to the three-edge bearing test as specified in Sec. 8.4, to support not less than the load indicated in Table 2.

TABLE 2

Crushing Strength

Nom. Diam. *in.*	Applied Load per Foot of Length—*lb*		
	Class 100	Class 150	Class 200
4	4,100	5,400	8,700
6	3,900	5,400	9,000
8	3,700	5,500	9,300
10	3,700	7,000	11,000
12	4,000	7,600	11,800
14	4,400	8,600	13,500
16	4,800	9,200	15,400
18	5,200	10,100	17,400
20	5,600	10,900	19,400
24	6,300	12,700	22,600
30	7,500	15,900	28,400
36	8,800	19,600	33,800

Sec. 8—Sampling and Testing Methods

8.1. *Test specimens.* All pipe and couplings tested under this specification shall be in a normal air-dried condition.

8.2. *Hydrostatic tests.* Each standard, random, and short length of pipe and each coupling sleeve shall be tested under an internal hydrostatic pressure as follows:

Class	Pressure *psi*
100	350
150	525
200	700

The water pressure shall be applied gradually and maintained at the specified test level for at least 5 sec. Any pipe or coupling sleeve showing any leakage, sweating, or other defect shall be rejected.

From each 300 lengths of pipe, or fraction thereof, of each size and class, which have passed the routine hydrostatic and flexural tests, one length shall be selected by the inspector. Each selected length shall be hydrostatically tested to a pressure of four times the rated working pressure for the class of pipe, such pressure to be maintained for at least 5 sec. The pipe shall not fail under this pressure. Each pipe so tested shall be retested in the manner specified in the paragraph immediately preceding.

8.3. *Flexure tests.* Each standard length of pipe of 4-, 6-, and 8-in. nominal diameter shall be tested in flexure. The supports shall be 12 ft apart. The total load shall be divided equally and applied at the third points of the clear span. Each pipe so tested shall support, without evidence of cracks or other defects, the applicable total load shown in Table 1. The load shall be applied at a uniform rate.

8.4. *Three-edge bearing tests.* When specified by the purchaser, from each 300 lengths of pipe, or fraction thereof, of each size and class, one length shall be selected by the inspector for a three-edge bearing test. From each selected length, there shall be cut one unmachined section of pipe 1 ft long. This section shall be tested by the three-edge bearing method and shall not fail until the total applied load exceeds the applicable value shown in Table 2. After 75 per cent of the specified load is reached, the load shall be applied at a uniform rate of approximately 2,000 lb per minute.

For this test, the two lower bearings shall consist of two straight wooden strips with vertical sides, each strip having its interior top edge rounded to a radius of approximately ½ in. The strips shall be securely fastened to a rigid block, with the interior vertical faces parallel and a distance apart of not less than ½ in. nor more than 1 in. per foot of diameter of the pipe. The upper bearing shall be a rigid wooden block, at least 6 in. by 6 in. in cross section, straight and true from end to end. The upper and lower bearings shall extend the full length of the test section.

8.5. *Machines for testing.* The machine used for the hydrostatic tests shall have gaskets that seal the ends of the pipe without materially counteracting the hydrostatic test pressure.

The machines used for the flexure and three-edge bearing tests shall be substantial and rigid throughout, so that the distribution of the load will not be appreciably affected by the deformation or yielding of any part of the machine.

8.6. *Retests and rejection.* The failure of any specimen tested for crushing strength to support 75 per cent of the crushing load required in Sec. 7.3 shall

be cause for rejection of the entire lot of that size and class manufactured during the same shift as the test specimen.

If any specimen tested for crushing strength supports more than 75 per cent but less than 100 per cent of the crushing load required in Sec. 7.3, one specimen shall be cut from each of five additional pipe sections of the same size and class manufactured during the same shift and shall be subjected to the crushing test. The failure of two of these additional specimens to meet the crushing strength requirements of Sec. 7.3 shall be cause for rejection of the entire lot of that size and class manufactured during the same shift as the test specimens.

If any pipe subjected to the higher hydrostatic test fails to withstand the specified pressure, five additional lengths of the same size and class shall be selected from the pipe manufactured during the same shift and shall be subjected to the higher hydrostatic test. The failure of two of these additional lengths to withstand the specified pressure shall be cause for rejection of the entire lot of that size and class manufactured during the same shift as the test lengths.

Sec. 9—Marking

9.1. Each standard and random length of pipe shall be clearly marked on the outside surface with the trade name, nominal inside diameter, class, hydrostatic test pressure, and date and shift of manufacture.

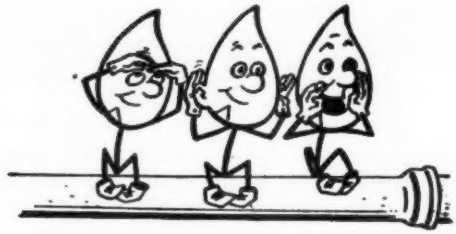
9.2. Each short length of pipe shall be clearly marked on the outside surface with the nominal inside diameter, the class, and the letter *T* to indicate that it has been hydrostatically tested.

9.3. All component parts of each coupling shall be clearly marked with the make and the size and class of pipe for which they are intended. Each coupling sleeve shall also be marked with the letter *T* to indicate that it has been hydrostatically tested.

9.4. When factory inspection is made by the purchaser, each pipe and each coupling sleeve shall receive an additional special marking of no more than three letters, as required by the purchaser.

Sec. 10—Preparation for Shipment

All pipe and couplings shall, unless otherwise specified, be prepared for standard commercial shipment, so as to insure acceptance by common or other carriers.



Percolation and Runoff

Straight Arrow, heap big Shawnee of the Shredded Wheat, has been dispensing Indian lore at the breakfast table for many, many moons by now. Of course, if you haven't eaten Nabisco's "original Niagara Falls" product you just won't know how to pitch a tent, build a footbridge, make a litter, or any other of the more than 100 "Injun-uities" of camping, fishing, and hunting so far described on the cards that separate the layers of those "dee-lishus" shredded wheat biscuits. That, my braves, is your misfortune. But even if you're one of those helpless Post Toasties eaters, we cannot in good conscience fail to give you the benefit of Straight Arrow's straight dope on Card No. 11, Book Four, entitled "Drinking Water." Although we can't draw the pictures of the thermos, canvas water bags (light), canteen, boy by stream, and Straight Arrow boiling water over a campfire for five minutes, we can give you the accompanying text:

One of the most important things, when camping out, is to be sure the drinking water is safe. Carry your water with you in jugs, canteens, or other containers, unless you are with a counselor, scoutmaster, or parent who knows safe areas.

Never drink from lakes or streams unless some authorized person gives you permission. There may be typhoid, cholera, and other dangerous contractible diseases in the water, especially if it is near human habitation.

When camping away from an authorized site, PLAY SAFE, and BOIL your water. . . . Wilderness water is usually all right, but don't take chances. Running water may clarify itself, but clearness does not necessarily indicate safety.

Straight Arrow say "How"; we say "And How!"

Home maid is the American woman, *she* says; but even we were surprised to note that more than 75 per cent of them do all their laundry at home, 4 per cent use a neighborhood automatic laundry, and less than 1 per cent send all their wash to a commercial laundry. Interesting marketing information for the water works man, as is the fact that the synthetic detergents have by now almost caught up with the soaps in production and sales, totaling some 1.8 billion pounds compared with 2.3 billion. The increase in synthetics in five years has been from 400 million pounds, a rise of 350 per cent, while soap sales dropped nearly 40 per cent. Thus the home maid is a modern maid, but she still plugs along with the oldest of the detergents as well—water, of course.

(*Continued on page 34 P&R*)

(*Continued from page 33 P&R*)

MEMBERSHIP METER
TOTAL
9 | 3 | 9 | 2
JUNE | 1 | 1953
AMERICAN WATER WORKS ASSOCIATION

Rainmaking makes little news these days. About the only new wrinkle of late has been the substitution of sea-salt spray for silver iodide in tropical seeding because the silver iodide nucleates only when the cloud peaks are below freezing in temperature. Thus, in Hawaii now, the territorial Board of Agriculture and Forestry is trying its hand at salting clouds' tails in an effort to help the drought-damaged sugar and pineapple industries.

Here at home, on the other hand, it is rain unmaking that is hitting the headlines. And, again, it is none other than Dr. Wallace E. Howell, celebrated as the $100-a-day rainmaker of New York City, who has contracted to prevent precipitation in the neighborhood of Palisades Amusement Park on the west bank of the Hudson River. Overseeding, to form so many nuclei in a cloud that the particles remain too small to fall, is the means by which Howell hopes to coax clouds to hold their water. How successful he will be is difficult to guess, but if the weather a few miles east of the Palisades is any indication, his Memorial Day inaugural was a complete washout. And if that nearby weather was merely a measure of his success in postponing Palisadistic precipitation, he should drop dead . . . twice!

Meanwhile, our more practical neighbors to the north have found a much more direct method of rainmaking, more reliable and more helpful than seeding of any kind. The technique is to drop paper containers of water, weighing approximately 35 lb each, upon incipient fires in the Canadian forests—a quick and effective means of holding fires in check until the fire protection forces can reach the scene.

Seeduction, reduction, and contraduction, but all of minor moment, and we must wait for the completion of the current U.S. Weather Bureau investigation for the real ruction in rainmaking.

The microfilm edition of the 1952 JOURNAL is fresh from the cameras of University Microfilms, 313 N. First St., Ann Arbor, Mich, which is offering it to regular JOURNAL subscribers and AWWA Members only at a cost of $7.95. The following earlier volumes are still obtainable: 1949, at $6.25; 1950, at $8.00; and 1951, at $6.35.

A glass of water these days can run to almost any size—anywhere, in fact, from the familiar $\frac{1}{16}$ gal to the tremendous 1,687-gal size now being used experimentally in five Navy minesweepers. The big ones, of course, are slightly different, in being closed at the top and being made of glass fiber, plastic reinforced. Running from a 100-gal size to that mentioned above, they are 30 to 40 per cent lighter than comparable metal containers and have the advantages of being nonmagnetic and resistant to corrosion. Of course, sailors have always been known for their drinking.

(*Continued on page 36 P&R*)

(*Continued from page 34 P&R*)

Divinity? Fudge! Or so say the disillusioned defenders of divining, now that an all-star aggregation of 38 California dowsers have bit the dust of San Clemente—the dust, that is, of two unassuming scientists who found plenty of water where "there was none," and proved there was none where "plenty could be found." Creator of this dust-bicuspid situation was San Clemente's water commissioner, Oland Carrick, who, needing a new well, decided to pit geology against rhabdomancy and, thereby, assure himself of results.

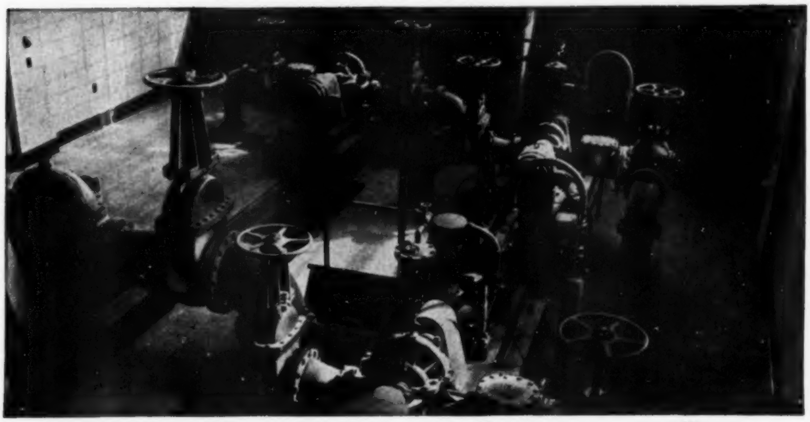
As noted in the March issue (P&R p. 42), once consulting engineer Loren Blakely and geologist John Stickel had pointed out what they considered the three best locations for a well, 38 dowsers were turned loose in the area. They, in turn, spotted 38 sure-fire well sites, none even near the scientifically selected spots. Subsequent test wells at the two preferred geologized sites both struck plenty of good water, while a hole sunk at a location agreed upon by at least six of the dowers was abandoned still waterless at twice the depth. Not just this failure, but the fact that the divine miscalculation, misjudgment, and misadvice continued all through the development of the 14-in., 980-gpm scientific well really caught up with the witches of San Clemente. And if "dammed if they're right and damned if they're wrong" is true, their well sites can continue to be called "sure fire."

"Reverse English" could well refer to the English thread—the left-hand thread—the one, that is, that closes counterclockwise. If it did, however, there'd be no end of Anglophobia, for left-hand threading of valves has been the cause of countless calamities in unmeant main closures, broken valve stems, and scaldings in the shower. Latest and no doubt greatest of the haters, though, would be the residents of Bound Brook, N.J., who have just completed 30 years of suffering on that account.

The Bound Brook bloomer is the story of a railroad underpass on one of the borough's main thoroughfares that always flooded so badly in rainstorms that vehicles couldn't get through. Thirty years ago residents got sick of the impasse and bought a pump to keep the water level at least low enough to permit continued use. During every storm for 30 years, the pump worked hard but ineffectually until just last year the borough decided to invest several hundred thousand dollars in developing a new modern drainage system. It was in investigating this possibility that the borough engineer thought to examine the pump and found the left-hand thread—meaning that the pump had been busily undoing its work for all that time. Next flood, perhaps, Bound Brook unbound, but meanwhile a curse on reverse English.

A command appearance is what AWWA exprexy Ross Dobbin put in at Westminster Abbey last month, when, as its president, he represented the Engineering Institute of Canada at the coronation of Queen Elizabeth. It was by command of Her Majesty through the Canadian secretary of state for foreign affairs, that Ross took flying leave of his own induction as Institute president to reach his place in the Abbey in time for the coronation ceremony. Good duty, that! So good, in fact, that Ross resigned his post as manager of the Peterborough, Ont., Utilities Com. to devote full time to it.

(*Continued on page 38 P&R*)



Modernization with Rensselaer

The Old Port Washington, Wisconsin, Water plant is now one of the most modern filter plants in the country.

The illustration shows the pump room, entirely equipped with Rensselaer gate and check valves. All gate valves 4 inch and larger in the entire plant are also Rensselaer.

Rensselaer products are well above specifications not only in general characteristics but in the thickness of metal at important points. They are designed with the "know how" which goes back to the early days of water systems, and they are built by technicians many of whom have been with the Company 35 years or more.

You don't have to build a new plant in order to modernize with Rensselaer. Ask our local representative why a replacement of a troublesome check valve will eliminate slam—why Rensselaer tapping sleeves save time, and why Rensselaer hydrants and valves will save maintenance on your service extensions.

Rensselaer VALVE COMPANY, TROY, N. Y.

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

A SUBSIDIARY OF NEPTUNE METER COMPANY

Sales representatives in principal cities

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(Continued from page 34 P&R)

Divinity? Fudge! Or so say the disillusioned defenders of divining, now that an all-star aggregation of 38 California dowsers have bit the dust of San Clemente—the dust, that is, of two unassuming scientists who found plenty of water where "there was none," and proved there was none where "plenty could be found." Creator of this dust-bicuspid situation was San Clemente's water commissioner, Oland Carrick, who, needing a new well, decided to pit geology against rhabdomancy and, thereby, assure himself of results.

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(Continued on page 38 P&R)

(Continued from page 36 P&R)

New construction for water works has hit a new peak for the first four months of 1953, according to an *Engineering News-Record* survey (issue of May 7). With $88,500,000 worth of construction contracted for in this period, the value of new projects is up 6 per cent over the previous year, while the $62,500,000 worth of projects proposed but not yet started is 18 per cent higher than the early 1952 total. Most of the new construction—approximately 80 per cent, in fact—is for the South and West. And a project backlog of $1,500,000,000 gives assurance against future declines.

Meanwhile, home building at rates that continue to set records, coupled with widening appliance distribution and continued industrial construction, promises to continue to raise water use, both absolutely and per capita. Whatever the significance of current uncertainties in finance and commerce, it appears that water works—and, with them, water works suppliers—are still on the upward slope of the business curve.

J. Beach Clow, vice-president of James B. Clow & Sons and president of the subsidiary Eddy Valve Co. and Iowa Valve Co., died on May 5 as the result of a heart attack. He was 49. The son of the late James Culbertson Clow, he had taken his place in the organization identified with the Clow family, and had found time also to be active in welfare and charitable groups in his native Chicago.

(Continued on page 40 P&R)

(Continued from page 38 P&R)

Time and Tide stoppeth on May 18 and April 25, respectively, to add their comments to the many already made (April P&R p. 33, June P&R p. 38) on the merits of the water pressure system of rating television programs. *Tide* came in with a story from superteeveed New York City, pointing out that rate of flow, rather than pressure, is the measure of listenerity there. Then *Time* told a characteristically candid tale of the "Teleflush Index" and how it grew. Both agreed with everyone else that "I Love Lucy" was far and away the biggest flow slower or pressure dropper. All of which would seem to indicate that if you have a TV set, on any Monday night at 9:30, "we know where you're going."

A safety first was established last month by the Akron, Ohio, water department in winning the National Safety Council Award of Honor for the year 1952. When Wendell LaDue, superintendent and chief engineer, accepted the plaque on behalf of the 232 employees of his department, it was the first time that any branch of government had won this highest citation in the field of safety. What it represented was 447,095 hours of work with only one lost-time accident, a rate of 2.2 injuries per million man-hours worked. And what it earned in addition to the award was a special resolution by "the mayor and council-as-a-whole" congratulating the department on being the nation's safest place to work.

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John G. Hoyt Jr., district sales supervisor for Rockwell Mfg. Co. in Houston, Tex., has been appointed assistant sales manager of the Water Meter Div. He joined the firm in 1941, as the result of a merger with the National Meter Co., with which he had served since 1939.

Disanonymization left us dismayed when we discovered that the author of those four untitled lines of rhyme surreptitiously distributed with the water bills to 30,000 residents of Sioux City, Iowa, was the same John L. Ford, whose "Colossal Bargain" we printed right next to them in last month's P&R (p. 37). The dismay, of course, was at our own obtuseness in failing to recognize either the style or the name, "Running Water," which is of Ford fabrication. Fortunately, it was the appearance of the complete text of "Making Running Water Run," in the thirty-eighth annual report of the Elmira, N.Y., Water Board, rather than the wrath of friend Ford, that identified the lines as further reason for calling him AWWA's Rhymer Laureate.

No threat at all to take that title was state senator Edward Chase of Maine, who nevertheless penned these water lines in arguing against a bill to exempt water from the state's 2 per cent sales tax:

If tax exemptions grow and grow
The revenues will melt like snow,
So
Let's keep the tax on H_2O!

(Continued on page 44 P&R)

(Continued from page 42 P&R)

A pipe fitting template for the drafting room, known as Cassel Pipe Fitting Indicator No. 253, has been produced by Graphic Indicator Co., 1739 S. La Cienega Blvd., Los Angeles 35, Calif.

Rivers staying 'way from their doors have caused considerable concern of late to the citizens of Decatur, Neb., Onawa, Iowa, and Laredo, Tex. Connecting the first two of these cities is a bridge built to span the wide Missouri, but just recently the House Appropriations Committee refused to vote the funds to divert the river under the bridge according to plan. And at Laredo, the Rio Grande, which is the source of the city's water supply, vanished one night leaving a dry and empty bed. Between "Whither River" and "Wither River," the latter is certainly far more serious, for the meandering of the Missouri is merely inconvenient, whereas the siltation and general inadequacy that have made the Rio Grande an international problem in both engineering and statesmanship now pose a problem of life and death to Laredo. What price water, indeed!

George S. Sangdahl has been elected a vice-president of Chicago Bridge & Iron Co., and shortly afterward became manager of a new sales office the firm has opened in the Alcoa Bldg., Pittsburgh, Pa. He has been associated with the firm or its Canadian affiliate, Horton Steel Works Ltd., since 1915.

(Continued on page 46 P&R)

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James J. Corbalis Jr., sanitary engineer of Fairfax County, Va., for the past 10 years, has been appointed engineer-director of the Alexandria, Va., Sanitation Authority. The authority was created last January and is the first to be established under legislation enacted in 1950 to enable communities to finance, construct, and operate sewers and sewage treatment systems.

Spickard's spigots sputtered and failed last May 11, and the 600 Missourians who populate the place were really *shown*, having to haul their own for twelve full days while the pump that had collapsed and caused the calamity was being replaced with a new one. Homes and business institutions, meanwhile, lived out of cream cans—capacity, 10 gal—and the only quantity user—a locker plant—managed to keep going by importing its 1,000 gpd via truck from a nearby farm. Fortunately, there were no fires nor extreme heat or cold, so the showing was a relatively comfortable one—proof, certainly, that with good neighbors, good weather, and good luck to stand by, who should need a pump?

Weber, Fick & Wilson is the name of a firm of public utility consultants organized to do appraisals, depreciation and rate studies and other reports and investigations. Principals of the firm, which has its headquarters at 1529 N. 2nd St., Harrisburg, Pa., are George Weber Jr., Henry H. Fick, and Robert E. Wilson.

Correspondence

Milk Teeth

To the Editor:

The fluoridation articles in the April 1953 issue of the JOURNAL AWWA were very interesting and I was pleased to note that the arguments of Bratton on the industrial aspects of fluoridation and McKee on fluoridating milk were so well answered by Weir and Sawyer, respectively.

Dr. McKee's conjecture is an interesting one, but in view of its extremely tenuous nature, it should not be allowed to confuse further a public that is already confounded with unsupported statements made on the basis of notions rather than facts. As a dentist, I believe it is important to add to Sawyer's penetrating discussion by citing what is probably the most serious objection to the fluoridation of milk: There is no published evidence which demonstrates that the addition of fluoride to milk, or to any other food for that matter, will result in a reduction in dental caries that would compare in magnitude with reduction observed consistently in areas where adequate fluoride is present in the water supply.

Partly as a result of one of Dr. McKee's earlier efforts along the same line, a paper entitled "Untested Alternatives to Fluoridation of Domestic Water Supplies," by Pearlman, was published in the *Journal of the American Dental Association* (**46**: 287, March 1953). This article emphasizes that at present we have no direct knowledge concerning the possible efficacy or safety of milk fluoridation, and it points out that extensive research studies would have to be performed to test this hypothesis. Considering the fact that, at present, water fluoridation is the cheapest, simplest and most direct method of achieving effective caries reduction on a popular basis, the article questions the advisability of spending the necessarily vast amounts of time, energy, and resources, in an attempt to find a "harder way," at this time. Reprints of Dr. Pearlman's article may be obtained by writing to the office of the American Dental Assn.

The American Dental Assn., along with most professional and scientific organizations, strongly encourages research in the field of public health; but at the same time, it has an obligation to protest against the dissemination of unsound hypotheses and untested theories where the public interest is at stake.

W. PHILIP PHAIR, D.D.S.

Assistant Secretary
Council on Dental Health
American Dental Assn.
222 E. Superior St.
Chicago 11, Ill.; May 14, 1953

To the Editor:

I am a little disturbed about the increased emphasis put on the possibilities of fluoridating milk. I have been told that in answer to a question put to him at the Grand Rapids conference, Mr. McKee gave Dr. McClure as his authority for saying that the fluoride in milk would be as readily available as fluoride in a water supply. This is not exactly what Dr. McClure wrote him. Dr. McClure said that he saw no reason why fluoride added to milk would not be readily available for assimilation. The fact is, experiments have not been done to prove this point. Although I personally believe also that fluoride added to milk should be readily available, in this regard, as you know, theory is not always proved by experimental facts.

F. A. ARNOLD JR.

Director
National Inst. of Dental Research
Public Health Service
Bethesda, Md.; May 21, 1953

The Reading Meter

Manual on Industrial Water. *Special Technical Pub. 148, American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa. (1953) 336 pp.; $4.25*

This useful volume, the product of ASTM's Committee D-19 on Industrial Water, was produced for the industrial water user and his technical personnel. Although the text surveys the various problems faced by industry in incorporating a useful—and, as always, troublemaking—raw material into its processes, the bulk of the volume is composed of reprints of ASTM standards for sampling and analyzing waters.

It is extraordinary that no reference was made to *Standard Methods,* particularly in the light of the introductory statement that the manual "will not replace an adequate library on the subject, . . . but it does provide basic information for routine use and gives direction into the technical literature, thus serving as a point of departure for more specific and detailed studies."

The Industrial Utility of Public Water Supplies in the South Atlantic States. *E. W. Lohr et al. Circular 269, Geological Survey, Washington 25, D.C. (1953) 162 pp.; paperbound; free*

This seventh of the projected series of nine reports (see "Reading Meter" for October and December 1952, and January and May 1953) describes the public water supplies in the states of Maryland, Delaware, Virginia, West Virginia, North and South Carolina, Georgia, and Florida. Information is provided on the ownership, source, capacity, storage, and treatment process of each utility, together with chemical analyses of both raw and finished waters.

Industrial Wastes: *Their disposal and treatment. Willem Rudolfs, ed. American Chemical Society Monograph Series, No. 118. Reinhold Publishing Corp., New York (1953) 497 pp.; $9.50*

This study of the problems posed by industrial wastes and methods of treating them has been broken down into a chapter-by-chapter study of various industries, with each special field treated by a different author. In addition to those familiar wastes-producers, the pulp and paper, coal mining, steel pickling and plating industries, there are chapters devoted to milk products, canning, meat packing, brewing, tanning, textiles, acids and explosives, petroleum, and nuclear fission and radioisotope use. Related industries are discussed along with the major topics, and a catch-all chapter gathers together the minor sources of pollution.

Fluoridation Facts: *Answers to criticisms of fluoridation. Div. of Dental Health Education, American Dental Assn., 222 E. Superior St., Chicago 11, Ill. (rev. February 1953) 23 pp.; paperbound; single copies free*

This factually written, yet obviously partisan booklet meets the fluoridation opposition head-on, on its own ground, and whatever social objections said opposition may retain, it is clear that the technical objections considered are thoroughly demolished. That the battle will not slacken just because a few weapons have been destroyed, however, is attested by the fact that this is just the latest version, we understand, of a booklet that has been expanded from time to time as new arguments are raised.

(Continued on page 52 P&R)

The Reading Meter

(Continued from page 50 P&R)

How to Obtain Fluoridation for Your Community Through a Citizens' Committee. *Div. of Dental Health Education, American Dental Assn., 222 E. Superior St., Chicago 11, Ill. (1952) 18 pp.; paperbound; single copies free*

Overlooking the subject matter of this pamphlet for the moment, and considering it purely as a manual in practical public relations work, it is a useful and practical guide, from which many lessons might be learned. As for the subject matter, that will be helpful to the water works man not so much in obtaining fluoridation—since we assume that the role he adopts is that of waiting to be asked—as in reassuring jittery segments of the public after it is started.

Washing Our Water: *Your job and mine. Helen Beal Woodward. Public Affairs Pamphlet 193, Public Affairs Committee, Inc., 22 E. 38th St., New York 16, N.Y. (1953) 28 pp.; paperbound; 25¢*

An outstanding job of high-level popularization has been done in this well-written, technically sound call to arms. Intended to stimulate civic groups to action, the booklet surveys the history, scope, legal aspects, and cost of the pollution problem in an incisive, indelible way. The problems of both waste treatment and water purification are touched on, and are summarized by an apt quotation from Mark Hollis that "As the pollution has increased, we have raised a protective wall against it, but some day that wall may have to go so high that it cannot be built." As the statement appeared in the JOURNAL (March 1952, p. 173), it was worded a little less strongly, but there is no quarreling with its general meaning.

Finally, Mrs. Woodward offers a "success-story" incentive to action by citing the experience of Florence, Ala., which learned the facts, had experts draft a plan, and roused itself to approve a bond issue by an overwhelming three-to-one vote. Well done, Florence—and a "well done," too, for all those responsible for this booklet.

Water Pollution Control: *Progress report for 1950 through 1952. WPCB Pub. 5, California State & Regional Water Pollution Control Boards, 305 Financial Bldg., Sacramento 14, Calif. (1952) 58 pp.; paperbound; free*

This three-year report of the work done since the passage in 1949 of California's "Dickey Water Pollution Control Act" makes interesting, encouraging reading. Seven of the state's 14 critical pollution situations existing before the board began its work have been cleared up; work is being done or is planned on the remainder. Voters have approved 72 individual bond issues for an aggregate of $55,000,000 of sewage works construction, and 156 communities invested $163,000,000 in facilities. Leading up to these accomplishments, and others still to come, have been the state and regional boards' activities in fact-finding, research, and coordination.

Basic Mechanics of Fluids. *Hunter Rouse & J. W. Howe. John Wiley & Sons, New York (1953) 245 pp.; $4.50*

One hesitates to recommend yet another book that will mean but deep water to many. Yet until one knows where the line is to be drawn, a persuasive case can be presented for the mastery of fluid mechanics as a basic working tool for those whose job it is to move water. Throughout this undergraduate engineering text, the authors, drawing upon their experience at the University of Iowa and its Institute of Hydraulic Research, have attempted a unified development of hydraulic principles and their applications, illustrated by working problems that are often recognizable and real. Definitely not for the casual reader.

(Continued on page 54 P&R)

The Reading Meter

(Continued from page 52 P&R)

Man and Epidemics. *C.-E. A. Winslow. Princeton University Press, Princeton, N.J. (1952) 246 pp.; $4*

It may make the water works operator uneasy to find a chapter on "The Problem of Pure Water" in a book with the ominous title of *Man and Epidemics,* but this is no hostile discussion. The author, who is editor of the *American Journal of Public Health,* concludes this section of his popularization with the comment that, "so far as public supplies are concerned, water borne disease in this country is a thing of the past." The book is intended for the layman, and its historical account of the development of purification practices and the epidemiology of specific, notable outbreaks—such as the Broad St. Well epidemic of cholera in London in 1854—will interest the specialist also, although there is nothing new in his compilation.

In fact, although such omissions are unimportant in a book intended for the general public, one misses an indication that such sources as M. N. Baker's *Quest for Pure Water* were consulted, and that recent developments have been taken into account. More culpable is the fact that the author leaves his reader with the distinct (but inaccurate) impression that the abortive addition of iodides to the Rochester, N.Y., water supply was but the first of many successful and continuing examples of iodization; whereas fluoridation is treated as a practicable public health measure which has not yet been adopted.

On the whole, however, the book is well and competently told, and it is likely that it will give many of its readers a new appreciation of the importance of "the water works" to their everyday lives—and the long continuance thereof.

Professional Services

Condensation

Key: In the reference to the publication in which the abstracted article appears, 39:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, 39:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

STERILIZATION

Applicability of the Lethal Properties of Ultrasound to Sanitary Engineering Practice. J. P. Horton, M. P. Horwood & D. E. Phinney. Sew. Ind. Wastes, **24**:457 ('52). Several types of ultrasonic generating equipment are briefly described. Most promising type seems to be barium titanate piezoelectric generator. Environmental temp. of bact. suspension is shown to have great importance in detg. ultrasonic killing rate. Extremely rapid killing was indicated in neighborhood of 140°F. Organic compounds such as proteins and other surface tension depressants have protective action against bactericidal effects of ultrasound. It is shown that ultrasonic killing rate is exponential function of surface tension, decreasing with diminishing surface tension. Turbidity of sewage and industrial waste limits effectiveness of ultrasound as bactericidal agent when turbidity is greater than 500 ppm. pH of liquid does not affect killing rate significantly during short time (20-min) exposures. For longer exposures, killing rate increases at higher pH levels. Pathogenic protozoa, such as cysts of *Endamoeba histolytica,* are rapidly destroyed by ultrasonic vibrations, time required for sterilization being approx. 0.5 min. Based on present cost considerations, bactericidal properties of ultrasound do not seem to be practicable in sanitary engineering field.—*PHEA*

Increasing the Oligodynamic Effects of Silver. G. A. Gesser. Gas- u. Wasserfach (Ger.), **93**:493 ('52). Finely divided Ag or Ag compds. destroy bacteria but action is so slow that process is not generally practical. Water contg. approx. 50 ppm NaCl was electrolyzed in Fe container (used as anode) with C or graphite cathodes, and with Ag rod or strip near cathodes; rate of destruction of bacteria was greatly increased—15 min rather than 4–6 hr—apparently due to formation of AgCl which penetrated cell walls and formed HCl. Ag was not connected to circuit, but apparently served as "intermediate conductor." No destruction of bacteria occurred with electrolysis in absence of Ag. Process requires further development before it can be economically used in competition with Cl water purif.—*CA*

Enhanced Effectiveness of Chlorination. K. H. Geiger & P. J. Moloney. Can. J. Pub. Health, **43**:359 ('52). Bactericidal effect of hypochlorites, halazone or chloramine T in presence of organic matter markedly increased by suitable concns. of ammonium ion. Optimum ammonium concns. depend on types and amts. of organic material. Enhanced bactericidal activity not due solely to formation of chloramines because amt. of ammonium ion required may be stoichiometrically several hundredfold that of added chlorine. Appears that ammonium ion acts as buffer in that it tends to prevent chlorine from being inactivated by organic material, leaving chlorine in form of simple chloramines and free to act as antiseptic. Ammonium ion may be supplied from either chloride, sulfate, nitrate, or phosphate.—*F. J. Maier*

Field Investigations of the Continuous Chlorination of Dug Wells. A. Szniolis & C. Kopczynski. Gaz, Woda i Tech. Sanit. (Poland), **25**:11:322 ('51). Purpose of studies: [1] to confirm on basis of study of large number of wells results of continuous chlorination of wells by feeding chlorine directly to wells; [2] to det. required dosages of chlorine for different wells; and [3] to det. effects of single-shot disinfection of wells on bact. content of well waters. 20 wells tested, all disinfected, and bact. samples taken to det. time required for wells to return to original bact. state. Wells divided into 4 groups of 5; in first 3 groups, chlo-

(*Continued on page 64*)


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A section of the pipe line connecting an inland reservoir with Corona Del Mar on the Pacific Coast. For this line, The Los Angeles Metropolitan Water District chose Reinforced Concrete Pressure Pipe, made by American Pipe and Construction Co. This view shows the installation of 36" Concrete Pipe with the Double Rubber Gasket Pressure Joint.

(*Continued from page 62*)

rine computed on basis of water consumed daily; in Group 4, on basis of vol. of water in well. Groups further treated as follows: Group 1, chlorine dosages added after single-dose disinfection of well; Group 2, chlorine dosage added after adding 0.5 ppm chlorine to water in well; Groups 3 and 4, no prior disinfection. In study, 141 chem. anals., 557 bact. anals., and 496 detns. of chlorine demand and various forms of chlorine in water were made. With single application of chlorine for disinfecting well, it was found that after 3–4 days bact. count was back to initial figure. Several days later rapid increase in count on gelatin and agar noted, followed by gradual decrease to initial count. Only 1 of 20 wells contained water that could be considered bact. safe. After treatment, 15 of 20 supplies were satisfactory as result of continuous chlorine additions. 5 remaining suffered mechanical and structural difficulties which made it impossible to treat water satisfactorily. Results of study are reported as follows: [1] bact. qual. of water, with continuous disinfection at proper dose level, can be maintained at satisfactory level in every dug well; [2] app. used, employing an inverted siphon filled with quartz sand, works satisfactorily for long periods of time and is not influenced by strong solns. of chlorine; [3] chlorine dose calcd. on basis of initial chlorine demand of water and vol. of water in well; [4] all dug wells improperly constructed are subject to continuous recontamination; [5] improvement in bact. quality following single application of chlorine for disinfection does not continue beyond 2 days; and [6] actual cleanliness of bottom of well exerts profound effect on bact. improvement of well.—*Conrad P. Straub*

Disinfection of Water Mains. W. H. Collier. Munic. Util. (Can.), **90**:12:14 (Dec. '52). In past, 4 pipeline disinfection methods used in Winnipeg, Man.: dry hypochlorite placed in main during constr., soln.-fed hypochlorite, Cl fed as gas, and Cl fed

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in soln. Latter now used exclusively, procedure being preliminary flushing, chlorination, flushing heavily chlorinated water from mains, and sampling. Recommended dosage 50 ppm, contact period 24 hr (may be reduced to 4 hr by increasing dosage to 100 ppm). Preliminary flushing should be at high rate to remove sediment. Trailer-mounted chlorination equip. described in detail. Cherry red color on addn. of 7 ml o-t soln. to 100-ml sample considered to indicate 50 ppm or more Cl. Use of drop diln. method in future proposed: 15-ml test soln. prepd. by adding distd. water to 0.5-ml o-t soln., and sample added dropwise (1 drop = 0.05 ml) until color obtained, which is measured in comparator:

$$\frac{\text{Cl in test soln.} \times 300}{\text{drops of sample}} = \text{ppm Cl}$$

After chlorinated water has stood in main required length of time, main flushed until Cl residual is that normally carried in system; main allowed to stand full 12–24 hr; then sample collected for each 100′ section of main by establishing flow-through time for 100′ main and sampling on lapsed-time basis. In Winnipeg, all new mains disinfected. Repaired mains not normally disinfected, but during and after '50 flood all mains shut down for repairs were chlorinated, using 150-ppm dosage and retention period of 1–2 hr to reduce out-of-service period. 10 feeder mains crossing river in Winnipeg controlled by valves on either side of river, with corporation cock close to one valve and riser close to other, for introduction of Cl and flushing, resp. In one main, after 3 treatments with up to 150 ppm Cl and retention periods up to 72 hr, samples still showed gas-forming (noncoliform) organisms and innumerable pinpoint colonies. Fourth treatment, 100 ppm, 24 hr, which included 1,000′ section upstream that had been idle except during flushing of river crossing, resulted in satisfactory samples.—*R. E. Thompson*

The Application of Chlorine in the Treatment of Water. E. A. Whitlock. Wtr. & Wtr. Eng. (Br.), **57**:12 ('53). Chlorine and water do not form simple mixture and waters to which chlorine is generally added are far from pure H_2O. Constituents of water supplies which have some bearing on problems of chlorination are: alkalinity due to carbonates and bicarbonates; oxidizable metals and other inorganic reducing agents; ammonia and amino compds.; oxidizable organic compds.; and bacteria and other biological elements. Carbonates and bicarbonates of calcium and magnesium resist change of pH by action of small amounts of acids and alkalis. This is particularly valuable where it is desirable to apply heavy doses of chlorine. Only metals that need be considered are Mn and Fe. Chlorine will not remove them unless pH is high enough for hydroxide formation. Nitrite has some significance as it is readily oxidized to nitrate by chlorine. H_2S in water can be oxidized in 3 stages, giving sulfur, sulfite, and sulfate. Only exceptionally would chlorine demand from this source be significant. When chlorine is added to water containing ammonia, one or more of these reactions may take place:

$$NH_3 + HOCl = NH_2Cl + H_2O$$
$$NH_3 + 2HOCl = NHCl_2 + 2H_2O$$
$$NH_3 + 3HOCl = NCl_3 + 3H_2O$$
$$2NH_3 + 3HOCl = N_2 + 3H_2O + 3HCl$$

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(*Continued from page 66*)

These chloramines have somewhat remarkable property that chlorine atoms contained therein are "available" and are chemically equivalent to original molecules of chlorine from which they arose. It may well be that all organic compounds are oxidizable in suitable conditions but it is evident that expression "chlorine demand" is meaningless unless it is qualified by "dose of chlorine" and "contact period." By far most important function which chlorine performs in treatment of waters is that of bactericide. According to present theory, death results from chemical reaction of HOCl with enzyme which is essential to life process of cell. Following are conclusions drawn from studies by author: [1] time of exposure to free chlorine and time of exposure to and concn. of chloramines were primary factors governing extent of bacterial kill; [2] killing power of free chlorine and chloramines diminished with increasing pH and rose with increasing temperature; [3] when effect of lowered temperature and high pH were combined, reduction in bactericidal efficiency was very marked; [4] to obtain 100% kill with same exposure period required approx. 25 times as much chloramine as free chlorine, and to obtain same kill with same amounts of chloramine and chlorine, former required approximately 100 times exposure period necessary for latter.—*H. E. Babbitt.*

A Transportable Chlorine Sterilizing Apparatus for Water Systems. W. Mohring. Bau u. Betrieb, **5**:2:4 ('53). Portable app. for prepg. HClO for sterilizing tanks, filters, mains, etc., is assembled on trailer and consists of 3 Cl cylinders, each holding 45 kg, 4-step circulating pump, aspirator for mixing Cl and water, and Vinidur tower filled with $CaCO_3$ to remove HCl after reaction of Cl with water. Large water tank was sterilized by spraying walls, roof, and floor with HClO soln. contg. 500 g Cl per cu m. Operator must wear protective clothing, but mask is unnecessary. With rapid sand filter, HClO addn. was equiv. to 50 g/cu m of water, and holding time 24 hr. Use of this method on mains is discussed and note is given on older method in which $Ca(ClO)_2$ is used. —*CA*

Emergency Method of Water Sterilization. A. Renshaw. Farm. Chilena, **26**:351 ('52). Iodine added at diln. of 1:20,000 destroys most pathogenic germs in 10 min. Excess of I can be removed by filtration through active charcoal.—*CA*

Experiences With New Oligodynamical Preparations for Disinfection of Water. M. Polster & K. Brazdova. Čzechoslav. farm., **1**:353 ('52). Ag compds. were studied as water disinfectants. Complex Na-Ag chloride, called Sag I, which decomp. in contact with water to give fine colloidal AgCl, gave best results.—*CA*

Decontamination of Water by Currents of Ultrahigh Frequency. V. F. Glibin. Gigiena i Sanit., **1952**:11:41. Bactericidal effects are noted on treatment of contamd. waters with 3–10-cm radio waves; 1–5-min exposure can result in complete or nearly complete destruction of microlife, with 10–12-kw app.—*CA*

BACTERIOLOGY

Limitations of Standard Bacteriological Methods in Evaluating Sanitary Quality of Water. F. W. Gilcreas. J. NEWWA, **66**:167 ('52). Author confines his attention to bact. procedures for examn. of water from 1890 on, sketching changes in definition and use of *Esch. coli* tests and development of coli-aerogenes group, later termed "coliform group." Changes in culture media and use of confirmatory tests supplementary to presumptive tests are noted. Greatest weakness of bact. examn. of water has been time required for test. Tendency has been to shorten technique. In 10th edition of *Standard Methods* now in preparation, use of lauryl sulfate tryptose broth will be recommended for certain waters in place of beef-extract lactose broth in presumptive test, but positive presumptive tubes must be confirmed by subsequent inoculation into BGB or other confirmatory media. Significance of aerogenes section of coliform group merits attention. Special methods for its differentiation are included in *Standard Methods,* but development of new differential tests for coli and aerogenes sections would not aid in evaluating sanitary qual. of water. For appraising qual. of public water supplies, treated or untreated, coliform group is useful. Presently established bacteriologic tests do not provide for detection and

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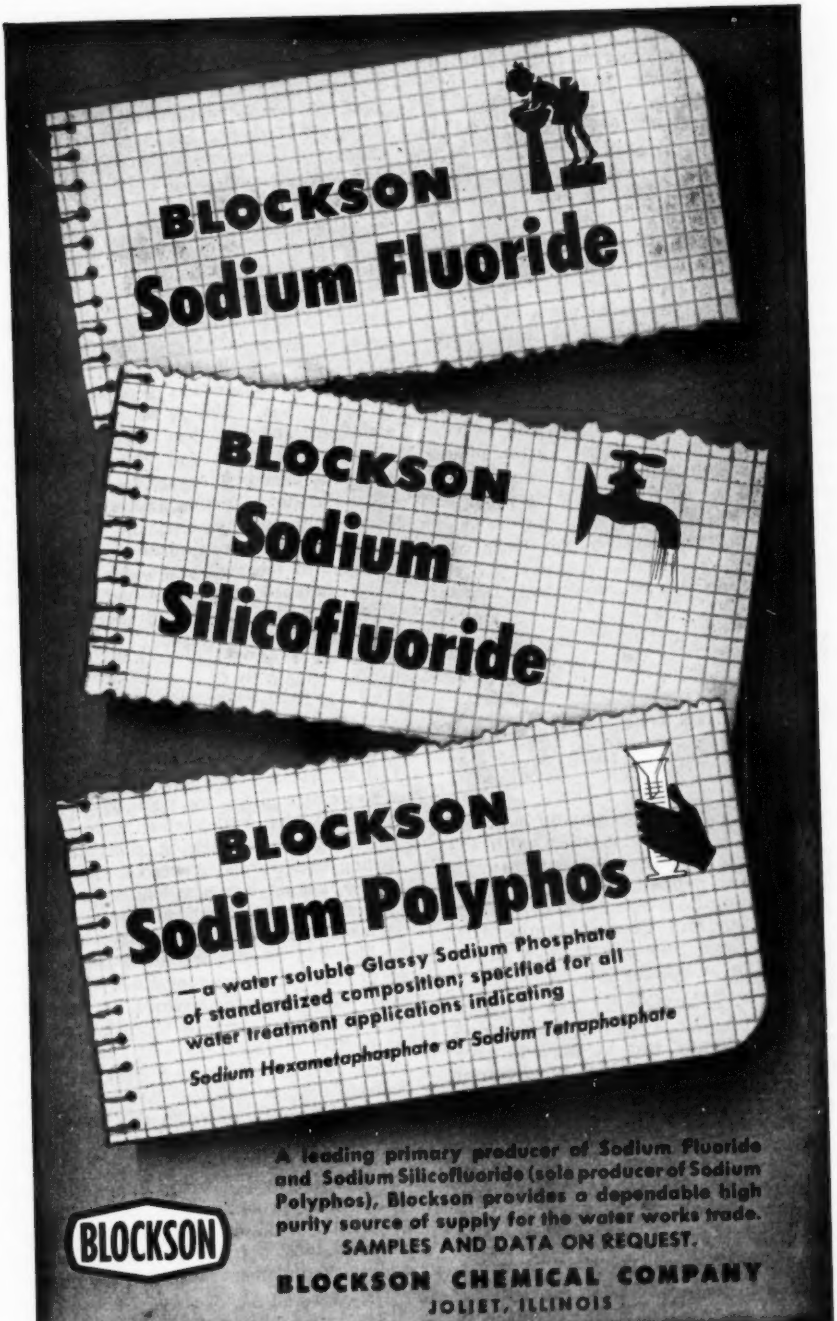
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(Continued from page 68)

enumeration of microorganisms which ferment lactose slowly, producing gas only after 72 or 96 hr or longer. Need for quantitative method for measurement of poln. of water was early recognized. After trials of various methods of expressing coliform densities, MPN index has been generally accepted. This is number of coliform microorganisms which more probably than any other number would yield observed lab. results. Author states that, in examn. of waters from swimming pools or bathing beaches, coliform group is of little importance, since significant bact. contamn. of water may not be intestinal in origin, but associated with other body discharges. Too little is known of quant. significance of fecal streptococci and other types. Quant. significance of virus in water is unknown. Use of plate counts at 20°C has been dropped, and apparently use of 37°C count (now made at 35°C) is on way out. Author emphasizes that validity of examns. in water is predicated upon integrity of sample and discusses effect of time and refrigeration. No change in requirements following collection of samples will be incorporated in 10th edition of *Standard Methods.* Standard procedures for examn. of water are not finally established; they have definite limitations which must be understood thoroughly. Value of lab. work is greatly reduced if individuals who interpret results are not thoroughly acquainted with limitations.—*PHEA*

Investigation Into the Survival of Anaerobic Bacteria in Sea Water. B. C. Callame. Ann. Inst. Pasteur (Fr.), **82**:377 ('52). Sea water was kept for 2 mo in order to "age," that is to say, to become stabilized, and was then dispensed in 20-ml vols. in test tubes and autoclaved. Bact. strains of anaerobic organisms were obtained from Pasteur collection and 0.5 ml of 24-hr broth culture of each strain was used as inoculum to observe survival of these organisms in tubes of sea water. 33 species were examined and most of nonsporing types died out within 24 hr. 15 species survived for 6 mo, mostly clostridial types which are found in fresh water and whose normal habitat is soil.—*BH*

Viability of *Escherichia coli* in Acid Mine Waters. J. M. Joseph & D. E. Shay. Am. J. Pub. Health, **42**:795 ('52). All waters of extreme acidities and pold. with fecal material and mine wastes which were examined support growth of few microorganisms, including bacteria and numerous fungi. *Esch. coli* is among bacteria which can sustain said conditions in small numbers. Its tolerance may be indicative of ability of typhoid bacillus and other waterborne pathogens to be present. Longevity of *Esch. coli* in acid mine waters was determined as substantial evidence of its tolerance. Rate of reduction on contact is rapid, but small number sustained 24-hr testing period even at pH 2.0. Self-purification studies were undertaken *in situ.* Factors active in this process are acidity, toxicity of compds. present, antagonistic action of microorganisms, food supply, and ingestion by protozoa. In spite of these unfavorable processes, self-purification is only partial and not complete. Public health measures must not be neglected on basis of acidity and other adverse conditions.—*PHEA*

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The Classification of Coli-Aerogenes Bacteria Isolated From Farm Water Supplies. S. B. Thomas, G. E. Jones & P. M. Franklin. Proc. Soc. Applied Bact., **14**:45 ('51). Gram-negative organisms were isolated from 142 samples of farm water supplies by means of incubation in MacConkey broth for 5 days at 30°C. In this way series of bact. types was obtained which fairly represented actual proportions of different types existing under natural conditions. Total of 384 Gram-negative cultures were isolated and divided into 4 main categories: [1] typical coli-aerogenes bacteria (54.2%); [2] anaerogenic cultures, producing acid but no gas in lactose peptone water at 30°C (2.9%); [3] nonlactose-fermenting strains (10.9%); [4] "unclassifiable" cultures, so called because they gave either both positive or both negative M.R. and V-P reactions (2.0%). These categories are discussed in detail. Systematic investigation of organisms resembling coli-aerogenes bacteria but failing to ferment lactose has been mainly confined in past to study of so-called paracolon organisms derived from human or animal sources. Results of present investigation again reveal high proportion in surface waters of bacteria resembling coli-aerogenes organisms in every respect but fermentation of lactose, and further investigation is highly desirable to determine their hygienic significance.—*BH*

Bacteriological Analysis of Drinking Waters. R. Buttiaux. Flammarion, Paris (Fr.) ('51). 209 pp. As regards bact. anal. of water, point has now been reached where most individual countries have standardized procedures within their own territories, but there still remain fundamental differences of procedure between countries. Time is not far distant, however, when effort should be made to standardize bact. anal. of water on international basis. It is expected that such advance will be difficult task, first, on account of language difficulty and, second (and more important), because it is often found that bacteriologists of one country are unaware of procedures of another country, so that it is impossible for them to assess relative eff. of each other's methods. This publication is therefore of great value from point of view of international standardization as it provides detailed and up-to-date account of methods favored by French bacteriologists for anal. of water. After reading book, one obtains clear idea of French practice, and it is apparent, with one or two exceptions, that methods are similar to those in regular use in Britain today. Routine bact. anal. of water samples described in this book includes total plate counts and tests for bact. indicators of poln. Gelatin is still favored for plate counts at 22°C, and colonies developing are differentiated into liquefying and nonliquefying and into fluorescent and nonfluorescent. With regard to examn. for fecal contamn., there are estns. of number of *Esch. coli* and other coli-aerogenes organisms, fecal streptococci, and *Clostridium welchii;* in addition, sample is examd. for coli-phage and dysentery-phage. Primary media used in isolation of coli-aerogenes group are Vincent's phenolized broth and American standard lactose broth; Kligler's complex iron agar medium plays important part in succeeding procedures for differentiation of organisms recovered from positive lactose broth tubes. Isolation and identification of bacteriophages are not carried out as routine on water samples in Great Britain but practical details set out in this book will be most valuable to those who wish to examine waters for presence of bacteriophages. In times of specific waterborne epidemics examn. under this head may be extended to search for phages of *Salmonella paratyphi B* and *Salmonella typhi* Vi. Later sections of book deal with special concn. and enrichment techniques for isolation of pathogenic organisms from pold. water. As well as including sections on *Salmonella* and *Shigella,* section on paracolon organisms gives detailed points for differentiation. Other organisms described are *Pseudomonas* (species *Ps. pyocyanea* is categorically described as being pathogenic), *Vibrio cholerae,* and *Leptospira.* Small section describes isolation of *Brucella tularensis* from water and isolation of poliomyelitis virus from sewage. Author has added to value of book by discussing hygienic significance of various organisms found in water, and frequent references are made to work published during past 2–3 yr, particularly with regard to recent work on paracolon group. Practical details of media making and various methods of isolation are simply described and

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should be easy to follow by those who wish to make use of some of methods described that are less well known outside France. —*BH*

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

Rating TV Programs by Water Demand. George Van Dorp. Pub. Wks., p. 64 (Mar. '53).

Effluent Rate Control for Rapid Sand Filters. C. G. Richardson. Wtr. & Sew. Wks., **100**:133 (Apr. '53).

Microstraining Proves Worth in England. A. W. Consoer. Eng. News-Rec., **150**:15:36 (Apr. 9, '53).

Problem of Softening Water at Low Temperature. R. A. Thuma. W.W. Eng., **106**:292 (Apr. '53).

Water Can Be Tailormade Before It Is Delivered. Eskell Nordell. W.W. Eng., **106**:295 (Apr. '53).

Water From Inside—City Wells. C. E. Wright. Pub. Wks., p. 70 (Mar. '53).

East Orange, N.J., Conserves Its Well Supply by Water Spreading. Malcolm Merritt Jr. W.W. Eng., **106**:286 (Apr. '53).

Stream Classification and Water Use Zoning. J. C. Frederick. Pub. Wks., p. 82 (Apr. '53).

East Delaware Tunnel: Gallery of Tunneling Techniques. Anon. Eng. News-Rec., **150**:13:32 (Mar. 26, '53).

Pneumatic Rollers Cut Costs and Time on Earthfill Dams. G. E. Bertram. Eng. News-Rec., **150**:14:30 (Apr. 2, '53).

New Bacteriological Technique for Testing Water and Sewage. J. H. Bush. Wtr. & Sew. Wks., **100**:151 (Apr. '53).


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Section Meetings

Montana Section: The 28th Annual Meeting of the Montana Section was held April 24–25 at Kalispell Hotel, Kalispell. Chairman A. L. Johnson called the meeting to order and Mayor D. M. McBride of Kalispell welcomed the members to the city and hoped their stay in Kalispell would be enjoyable. M. E. Henderson, past chairman, responded to the mayor's welcome. The chairman gave a brief address, and John B. Hazen, national director for the section, reported on the last Board of Directors' meeting in New York in January.

Charles Capen, AWWA president, commented on several subjects of interest to the members. He mentioned the vast help a person can receive by using the standard specifications drawn up by the AWWA committees.

The afternoon session on April 24th consisted of a round table discussion led by Chet Eyer and Rodney Praetor. A discussion of "Research in the Water Works Field" was first presented by E. R. Dodge, professor of civil engineering, Montana State College, Bozeman. He discussed the differences between practical and basic research, and mentioned as an example of completed research the McIlroy distribution system analyzer which utilizes an electrical analogy to simplify hydraulic computations.

"Highways and Water Works" was the title of a discussion by John Hazen, superintendent, Butte Water Co. The next discussion was on "Public Relations," presented by Richard Setterstrom, industrial engineer for the Montana Power Co. in Butte.

"Water Softening and the So-called Gadgets," a discussion by Claude Eyer, city engineer, Glendive, reviewed the problems involved in water softening and also mentioned some of the devices promoted for water conditioning that have hit the state of Montana. A discussion of "Practical Experiences in Pipe Laying" by Kurt Wiel, city engineer of Miles City, and Chet Eyer, distribution superintendent of Billings, discussed some method of freezing pipelines to halt flow during repair operations. At Miles City, butane gas is used as a refrigerant; at Billings, dry ice and gasoline are used.

The next topic on the round table was "Safety Practices" by Dave Thomas, district engineer for the Fire Underwriters of the Pacific. He limited his remarks to the reliability of pumping plant equipment and how important its continued operation is for the safety of the community.

The last topic was "The Status of Fluoridation in Montana Cities." M. E. Henderson, city manager of Bozeman, discussed the problems of setting up a program of fluoridation and getting the equipment installed. Carl King, city engineer of Chinook, discussed an operating program in Chinook, which has been fluoridating its water for the last year with satisfactory results.

The round table was followed by a business meeting, at which the reports of the appointed committees were received, new officers were elected, and that business of interest to the members was discussed.

The technical portion of the program continued on April 25th with a paper by President Capen entitled "The Outlook for the Water Works Industry."

C. W. Brinck, director of the Div. of Environmental Sanitation, State Board of

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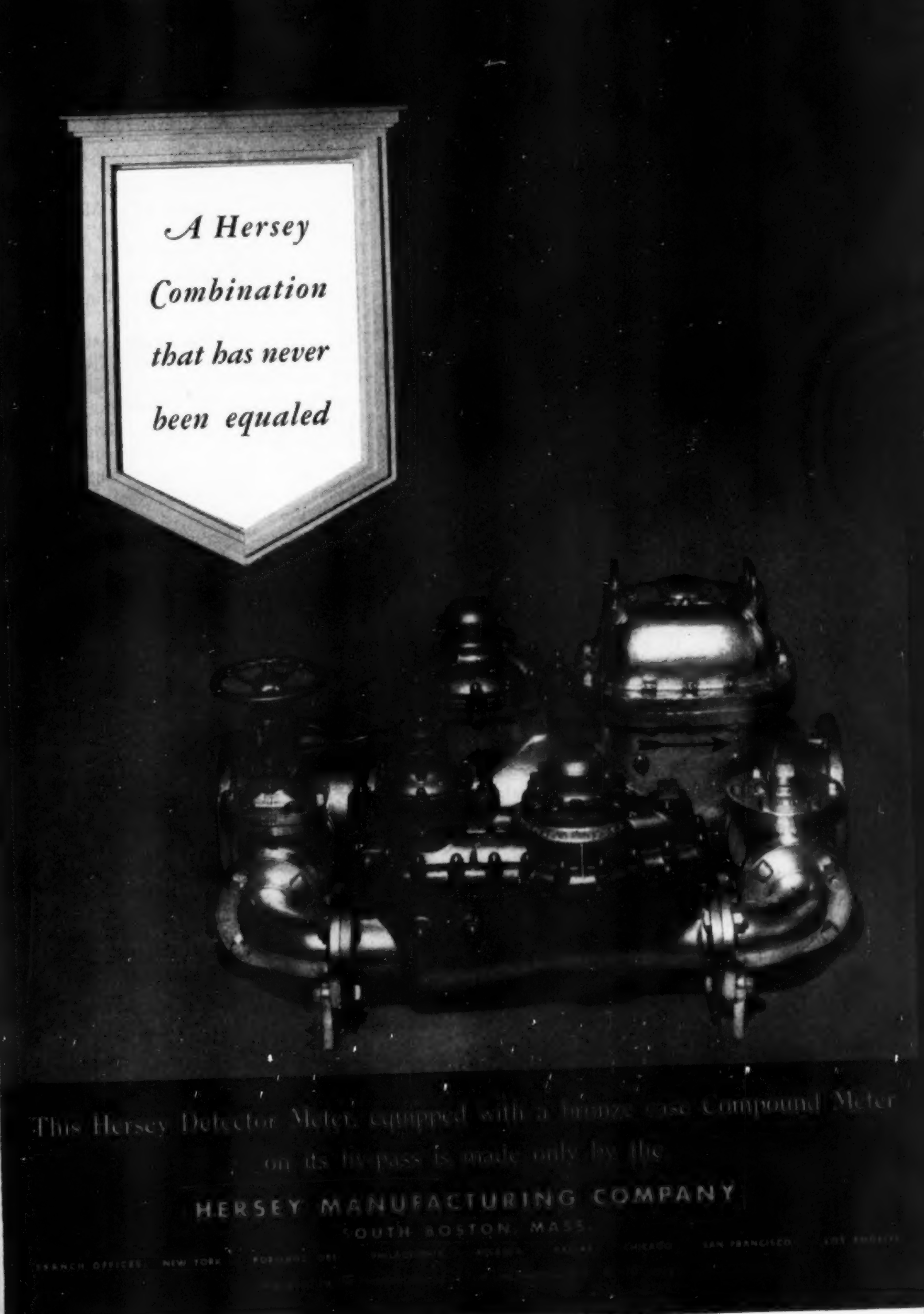

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Section Meetings

(Continued from page 76)

Health, gave a paper on "Nitrates in Drinking Water." Tom Robinson, principal engineer of Black & Veatch, Kansas City, Mo., spoke on "Present Trends in Water Works Construction."

After the technical session the group was convoyed to a sight-seeing trip in and about the Kalispell area; one of the points visited was the new Hungry Horse Dam construction a short distance from the town. The entertainment for the meeting consisted of a buffet supper on April 23rd and a dinner dance on April 24th. Fred Palmer was awarded the Fuller Award from the Montana Section at the dinner-dance, and H. B. Foote and Fred Quinnell were presented with certificates of Life Membership in AWWA for having maintained their good standing in the Association for 30 years.

A. W. Clarkson
Secretary-Treasurer

Illinois Section: An inspection field day sponsored by the Illinois Section and the State Dept. of Public Health was held on June 3 at Rockford, for the water works operators in the northern part of the state. The meeting depended upon demonstrations; no formal papers were read.

With 98 water works men and manufacturers' representatives attending, two large buses were used by Superintendent H. S. Merz to convey the group from one point of interest to another. Mayor Milton A. Lundstrom extended a hearty welcome to the city at luncheon, and afterwards a motion picture, "The Manufacture of Cast Iron Pressure Pipe," was shown by the James B. Clow Co.

The first point of interest on the tour was a demonstration of the installing of 12-in. "roll-on" joint cast-iron pipe. The next feature of the tour was the installation, under pressure, of an 8-in. valve in one of the 41-year-old cast-iron mains in the center of the Rockford business district. In another demonstration, about 12 minutes and 5 lb of dry ice were required to freeze copper service pipe enough to prevent loss of water during repairs.

Joe Byrd, the service repairman, proved an excellent speaker and demonstrator. He particularly aroused the interest of the group with some tools he had designed and made to shut off the water in services without reliance on valves. One, mounted on a slender rod about 2 ft long, could be inserted into a defective cock or service and adjusted from one end to expand a rubber gasket at the other end, thus shutting off the flow and permitting repairs to be made. Another was a clamp used to squeeze off lead and copper services.

Other features of the tour were the operation of an electronic pipe finder, the deep well pumping stations, the use of mechanical joint split sleeves for repairing pipe, and office procedures. A pleasant and rewarding time was had by all.

Dewey W. Johnson
Secretary-Treasurer

Service Lines

Mono-column demineralizers in which cation and anion exchangers are mixed in a single tank are described in a catalog sheet distributed by Penfield Mfg. Co., Inc., 19 High School Ave., Meriden, Conn. Known as the Model MA, the demineralizer unit is said to function and signal the need for regeneration completely automatically. Regeneration is then performed upon the turn of a switch.

"Plastiment," an agent for controlling gel formation in concrete and thereby, according to the manufacturer, permitting greater uniformity, crack resistance, water-tightness, and surface hardness of the concrete, is described in an 8-page booklet prepared by Sika Chemical Corp., 35 Gregory Ave., Passaic, N.J. Drawings and graphs illustrate the theory underlying the use of the product.

A chlorination guide, known as "Keep Sheet No. 13," is being distributed by Builders-Providence, Inc., 345 Harris Ave., Providence 1, R.I. In addition to describing the various methods and techniques available for applying chlorine, the leaflet defines frequently used terms and discusses the purposes and types of chlorination.

Maintenance procedures for electrical control equipment are outlined and described in an 8-page manual available on request from Allis-Chalmers Mfg. Co., 1026 S. 70th St., Milwaukee, Wis. Entitled "Proper Maintenance of Control," the booklet features helpful photographs of maintenance operations and includes a 26-point checklist for preventive maintenance.

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Two-way radio equipment for industrial applications is the subject of a booklet entitled "Instant Communication," published by the General Electric Co. and available from it at Electronics Park, Syracuse, N.Y.

A prestressed pipe check sheet has been prepared for pipe users by Price Brothers Co., 1932 E. Monument Ave., Dayton 1, Ohio. The sheet facilitates the relative evaluation of various types of pipe.

A sewage works number of the E-M Synchronizer is devoted to sewage pumping, but also includes a basic explanation of sewage treatment processes by Rolf Eliassen. The publication, of which this issue is known as No. 38, is distributed by Electric Machinery Mfg. Co., Minneapolis 13, Minn.

An automatic engine stop valve is described in Bul. S-3, a publication of Golden-Anderson Valve Specialty Co., 2091 Keenan Bldg., Pittsburgh 22, Pa. The valve is designed to operate on a steam line, and is controlled by governor speed or a limit switch.

A 250-page catalog of gates, valves, hoists, and other water control apparatus produced by Rodney Hunt Machine Co., 7 Water St., Orange, Mass., has just been issued and is available upon letterhead request from water works engineers, contractors, and others actively engaged in construction work. Sixteen chapters of this voluminous report are devoted to applications, design features, specifications, and installation of 2,000 combinations of standard types and sizes of sluice gates alone. A 28-page section is devoted to engineering data.

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Service Lines

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Conductivity and pH recorders and controllers are the subject of a 24-page catalog, No. 1550, available from Station 64, Brown Instrument Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Ave., Philadelphia 44, Pa. Also available are seven new specification sheets on flow meters.

"Book News," a house organ of Lange, Maxwell & Springer, Ltd., scientific, medical, and technical booksellers of 41–45 Neal St., London, W.C. 2, England, is offered to persons filling out a special "interest" card, available on request.

Pipe for special applications, fabricated to order, as well as structural and rail pipe, welding fittings, and well castings are described in a 16-page catalog, No. 575 C, offered by L. B. Foster Co., Box 1647, Pittsburgh 30, Pa.

A "Universal" holiday detector for the inspection of pipe coatings is described in a catalog sheet of the Petroleum Instrument Co., Box 6252, Houston, Tex.

The advantages of electric typing are described in a 16-page booklet, RE 8612, distributed by Remington Rand Inc., 315—4th Ave., New York 10, N.Y. Increased number of carbon copies, more uniform work, and reduction of operating fatigue are cited as reasons for increased productivity.

Pressure, temperature, and humidity controls, as well as pneumatic and electric valves, switches, and relays, are described in an 80-page catalog of industrial controls, No. 8305, issued by the Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Ave., Philadelphia 44, Pa.

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